40TH CONGRESS, } 3d Session. } HOUSE OF REPRESENTATIVES. { H. Ex. Doc. { No. 71.

REPORT OF THE SUPERINTENDENT

OF THE

UNITED STATES COAST SURVEY,

SHOWING

THE PROGRESS OF THE SURVEY

DURING

THE YEAR 1868.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1871.

IN THE SENATE OF THE UNITED STATES,
February 10, 1869.

Resolved, That there be printed, of the Report of the Superintendent of the United States Coast Survey for the year 1868, one thousand copies extra for the use of the Senate and one thousand copies for distribution by the Superintendent of the Coast Survey.

Attest:

GEO. C. GORHAM,
Secretary.

IN THE HOUSE OF REPRESENTATIVES,
February 12, 1869.

On motion of Mr. Laflin, from the Committee on Printing—

Resolved, That there be printed two thousand five hundred extra copies of the Report of the Superintendent of the United States Coast Survey for the year eighteen hundred and sixty-eight, of which one thousand shall be for distribution by the Superintendent of the Coast Survey and one thousand five hundred for the use of the House.

Attest:

EDWARD McPHERSON,
Clerk.

LETTER

FROM THE

SECRETARY OF THE TREASURY,

TRANSMITTING

ANNUAL REPORT OF SUPERINTENDENT OF COAST SURVEY FOR 1868.

FEBRUARY 5, 1869.—Referred to the Committee on Commerce and ordered to be printed.

TREASURY DEPARTMENT, WASHINGTON, D. C., *February* 2, 1869.

SIR: I have the honor to transmit, for the information of the House of Representatives, a report made to this Department by Benjamin Peirce, LL.D., Superintendent of the United States Coast Survey, on the progess of that work during the year ending November 1, 1868, and an engraved sketch showing the general progress made in the survey of the Atlantic, Gulf, and Pacific coasts; also the manuscript map of progress brought up to the same date, in accordance with the act of Congress approved March 3, 1853.

I have the honor to be, very respectfully,

H. MCCULLOCH,
Secretary of the Treasury.

Hon. SCHUYLER COLFAX,
Speaker of the House of Representatives.

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REPORT OF THE SUPERINTENDENT.

COAST SURVEY OFFICE, *December* 28, 1868.

SIR: In conformity with law, I have the honor to present the following report on the progress of the survey of the coast, under my superintendence, during the past year:

The various branches of the field-work have been in active operation in seventy different sites on the Atlantic, Gulf, and Pacific coasts of the United States, as will be seen by reference to the tabular statement which accompanies this report as Appendix No. 1.

During the year ending with the present month, progress has been made in the regular operations of the survey at Penobscot Entrance, and on the group known as the Fox Islands in Penobscot Bay, including also the Thoroughfare Passage; in the completion of work on the George's River and on Medomak River; in the completion of soundings in Muscongus Bay and near Kennebec Entrance; in extension of the survey of the Kennebec between Merrymeeting Bay and Augusta; in the detailed topography of islands in Casco Bay; in a minute survey of the vicinity of Munjoy Hill, (Portland,) for the city authorities; in a development of the vicinity of Half-Way Rock, (Casco Entrance;) and in general progress in Saco Bay, coast of Maine. On the sea-coast and inside of Cape Cod Peninsula, outstanding work has been completed by three parties; changes affecting navigation have been developed off Monomoy Point, Massachusetts, and two parties have continued the detailed survey of Narraganset Bay, in Rhode Island. In New York Harbor, a special examination has been made between Governor's Island and the Narrows, for the city authorities; and a survey to develop facilities for navigation at Rondout, on the Hudson River. Progress has been made in the coast topography of New Jersey, at Barnegat Bay. Two parties have been employed in defining and sounding the estuaries of Chesapeake Bay, and of the lower part of the Potomac; and a special examination has been made of shoals obstructing the navigation of the Rappahannock River. The primary triangulation has been in progress connecting stations near Washington City with others on the Blue Ridge. The off-shore hydrography has been prosecuted north of Cape Hatteras toward the Virginia line. In North Carolina, the detailed survey of the Neuse River has been completed, and triangulation and hydrography have been continued in Pamplico Sound. The triangulation south of Charleston has been connected with stations on the Savannah River, and progress has been made in the detailed survey of the branches of Port Royal Sound. On the coast of Georgia, St. Catharine's Sound, St. Andrew's Sound, and Doboy Sound have been surveyed, and soundings have been completed at the last-named entrance. Outstanding work in the vicinity of Barnes's Sound, Florida, has been nearly completed, and investigations of great interest have been prosecuted in the Florida Strait. Two parties have continued the survey of St. Joseph's Bay, (north,) and a third has been employed on the Gulf coast between Perdido Bay and Mobile Point. On the coast of Louisiana, the triangulation of Isle au Breton Sound has been completed, and soundings have been made in the bays and lagoons between the Mississippi Passes. Last Island has been connected by triangulation with the coast, and the true position has been determined of Ship-Shoal light-house, off Last Island. At Galveston, Texas, the longitude has been determined by the telegraphic method, in continuation of a series of observations terminating in a previous year at New Orleans. Soundings have been continued in Galveston Bay. At Lavaca, latitude, azimuth, and the magnetic elements have been determined, and the hydrographic survey has been continued in Corpus Christi Bay.

On the coast of California, the survey has been in progress between Point Conception and Buenaventura, and on the peninsula near San Francisco; on the coast of Oregon, at the Yaquina River, at Nehalem River entrance, and at Columbia River; and in the waters of Washington Territory, at Port Madison and Port Discovery.

ESTIMATES.

The attention of the country has been frequently called to the cost of the survey, and to the amount of time and labor which have been expended upon it. But a full reply is the simple fact that the value of the survey greatly exceeds its cost. Its results are cheaply purchased, and are fully appreciated by the mercantile community, who are ready enough to pay for them, having more than once expressed anxiety lest a mistaken spirit of economy should lead to injudicious restriction of the operations. To bring produce to the consumer is the object of trade, and everything that facilitates this object must be a public benefaction. To lessen the dangers of navigation is to diminish the expenses of each man's living; it takes from the price of every article which comes from foreign countries, and still more from the many domestic products carried to the consumer from the producer along the difficult or dangerous parts of our coast. Every new channel discovered is, when developed, an immediate addition to the wealth of the country. The consumer is at one end and the producer at the other, and both are equally benefited. Hence there is no State of the Union which has not a valuable interest in the survey of the coast. The agricultural products and manufactures of the interior States are not less interested in the coast trade than the merchants themselves, through whom the traffic is directly conducted. By the authority of Congress the survey may be carried "as far inland as the ports and harbors for commerce," and as far as "may be necessary for purposes of commerce." Now, there are, far in the interior, ports of entry, as upon the Mississippi and its tributaries. If these are not to be neglected, it is time to commence their survey; and it will be wise to decide at the outset whether operations shall be restricted to the simple demands of the hydrography, or whether they shall be extended as a geodetic survey, which may serve for the basis of geologic and other surveys to be made by the States, and which would be invaluable to engineers in the locating of railroads and other improvements.

The following estimates were submitted to the Department in October last. Like those of last year—compared with which they are somewhat diminished—they exceed the appropriations of preceding seasons. The estimate is, as nearly as possible, that which is requisite to maintain the most economical action without augmenting the present scale of the survey. It is the least amount that will keep the parties steadily at work and preserve this service in a constant state of useful activity. The laying out of the work is carefully adjusted to meet the commercial wants of the whole country, and is in strict accordance with the plan of progress which has been hitherto approved.

ESTIMATES IN DETAIL.

For general expenses of all the sections, namely: rent, fuel, materials for drawing, engraving, and printing, and for transportation of instruments, maps, and charts; for miscellaneous office expenses, and for the purchase of new instruments, books, maps, and charts $20,000

SECTION I. *Coast of Maine, New Hampshire, Massachusetts, and Rhode Island.*—FIELD-WORK.—To continue the triangulation of *Passamaquoddy Bay* and its branches, and to extend the work so as to include the northeastern boundary along the *St. Croix River;* to continue the topography of *Frenchman's Bay;* that of the islands and shores of *Penobscot Bay;* that of *Saco Bay;* and of the shores and islands of *Narraganset Bay;* to continue off-shore soundings along the coast of Maine, and the hydrography of *Frenchman's Bay*, *Goldsborough Bay*, *Penobscot Bay*, and *Isle au Haut Bay;* to continue tidal and magnetic observations. OFFICE-WORK.—To make the computations from field observations; to continue the engraving of general coast chart No. I, (*Seal Island to Cape Cod,*) and complete that of No. II, (*Cape Cod to Gay Head;*)

to continue the drawing and engraving of No. 4, (*Naskeag Point to White Head Light, including Penobscot Bay;*) that of charts Nos. 5 and 6, (*White Head Light to Wood Island Light;*) that of Nos. 7 and 8, (*Seguin Light to Cape Porpoise Light;*) and of coast chart No. 13, (*from Cuttyhunk to Point Judith, including Narraganset Bay;*) and to continue the drawing and engraving of the harbor and river charts of the coast of Maine, and of *Narraganset Bay*, will require $80,000

SECTION II. *Coast of Connecticut, New York, New Jersey, Pennsylvania, and part of Delaware.*—FIELD-WORK.—To make supplementary astronomical observations; to continue verification work on the coast of *New Jersey;* to continue the topography of the shores of the *Hudson River;* to execute such supplementary hydrography as may be required in *New York Bay* and *Delaware Bay;* to continue the tidal observations. OFFICE-WORK.—To make the computations and reductions; to continue the drawing and engraving of a chart of *New York Harbor* on a large scale; also of coast chart No. 21, (*from Sandy Hook to Barnegat;*) and of No. 22, (*from Barnegat Bay to Absecom Inlet,*) will require 15,000

SECTION III. *Coast of part of Delaware, and that of Maryland, and part of Virginia.*—FIELD-WORK.—To continue astronomical and magnetic observations in this section; to continue the primary triangulation parallel to the coast, from *Washington City* southward along the *Blue Ridge;* to continue the topography of the *Eastern Shore* of *Virginia*, and of the shores of *James River*, and triangulation requisite therefor; to make the hydrographic survey of estuaries and inlets remaining unsurveyed in this section; to continue tidal observations, and to make observations for determining the longitude of the *Pacific coast.* OFFICE-WORK.—To make the computations from field-work; to continue the drawing and engraving of coast charts Nos. 29 and 30, (*from Chincoteague Inlet to Cape Henry;*) and of general coast chart No. IV, (*approaches to Delaware and Chesapeake Bays;*) and to engrave supplementary work on the charts heretofore published, will require 35,000

SECTION IV. *Coast of part of Virginia and part of North Carolina.*—FIELD-WORK.—To complete, if practicable, the primary triangulation of *Pamplico Sound*, and to make the requisite astronomical and magnetic observations; to continue the triangulation and topography of the western shores and estuaries of *Pamplico Sound;* to complete the topography of the outer coast of *North Carolina*, between *Bogue Sound* and *New River Inlet;* to continue the in-shore and off-shore hydrography of this section; to continue soundings in *Currituck* and *Pamplico Sounds*, and their estuaries, and to make observations on the tides and currents. OFFICE-WORK.—To make the computations and reductions; to continue the drawing and engraving of general coast chart No. V, (*from Cape Henry to Cape Lookout;*) of coast charts Nos. 38 and 39, (*coast from Currituck Banks to Cape Hatteras;*) of Nos. 42, 43, and 44, (*Pamplico Sound and estuaries;*) of Nos. 45 and 46, (*coast from Cape Hatteras to Cape Lookout;*) and of charts of the *Neuse River* and *Pamplico River*, will require 35,000

SECTION V. *Coast of South Carolina and Georgia.*—FIELD-WORK.—To make the requisite astronomical and magnetic observations on the coast of Georgia; to extend the topography from *Winyah Bay* to *Cape Romain;* to complete the topography from *St. Simon's Sound* southward to the *St. Mary's River;* and to sound the interior water-passages among the Sea Islands from *Sapelo Sound* southward, and continue off-shore hydrography and the tidal observations. OFFICE-WORK.—To make the computations; to continue the drawing and engraving of the general coast chart No. VII, (*from Cape Romain to St. Mary's River;*) of coast charts Nos. 56 and 57, (*from Savannah River to St. Mary's River;*) and of charts of *Altamaha Sound, St. Andrew's Sound*, and the inland tide-water communication on the coast of *Georgia*, will require 40,000

SECTION VI. *Coast, keys, and reefs of Florida.*—FIELD-WORK.—To determine the longitude of several points on the west coast of *Florida;* to continue the triangulation and

topography from *Matanzas Inlet* southward to *Mosquito Inlet;* to complete the survey of the keys and sounds between *Key Largo* and *Cape Sable;* to commence the survey of *Tampa Bay;* to continue the hydrography of the *Florida Reef*, between the *Marquesas* and the *Tortugas*, and that of the *Strait of Florida;* to complete the hydrography of the *Bay of Florida*, and to make tidal and magnetic observations. OFFICE-WORK.—For computing from field observations; to continue the drawing and engraving of off-shore chart No. XI, (*western part of Florida Reef, including the Tortugas;*) of coast charts Nos. 75 and 76, (*from Caloosa Entrance to Tampa Entrance;*) and of coast charts Nos. 70 and 71, (*Key West to Tortugas,*) will require.......... $35,000

SECTION VII. *Western coast of Florida, peninsula north of Tampa Bay, and coast of West Florida.*—FIELD-WORK.—To continue the triangulation from *Cedar Keys* toward the *Suwanee River;* from *St. Andrew's Bay* toward *Chattahoochee Bay;* and to make such astronomical and magnetic observations as may be required; to continue the topography to the westward of *St. Andrew's Bay* and that of the *Gulf coast* adjacent to *Santa Rosa Sound;* to survey and sound the entrance to the *Suwanee River;* to complete the hydrography of *St. George's Sound;* and to make soundings off *Cape San Blas*, and continue the tidal observations. OFFICE-WORK.—To make the computations from field-work; to continue the drawing and engraving of coast charts Nos. 82 and 83, (*from Ocilla River to Cape San Blas;*) and of No. 89, (*from Pensacola to Mobile Point;*) and to prepare a chart of the approaches and entrance to *Suwanee River*, will require.......... 30,000

SECTION VIII. *Coast of Alabama, Mississippi, and part of Louisiana.*—FIELD-WORK.—To continue the triangulation from the *Mississippi Delta* westward, and to make the astronomical and magnetic observations required in this section; to commence triangulation for the survey of the *Mississippi* and its tributaries in the vicinity of *St. Louis, Cincinnati*, and such other points as may be practicable; to complete the survey of the shores of *Isle au Breton Sound*, and of the adjacent banks of the Mississippi; to continue the hydrography within the same limits and that of *Lake Borgne* and *Lake Pontchartrain;* and to make tidal observations. OFFICE-WORK.—To make the computations pertaining to field-work; to continue the drawing and engraving of the general chart No. XIV, (*Gulf coast between Mobile Point and Vermilion Bay;*) of coast charts No. 91, (*Lake Borgne and Lake Pontchartrain;*) Nos. 92 and 93, (*Chandeleur Island to Southwest Pass;*) and No. 94, (*Mississippi Delta,*) will require.......... 50,000

SECTION IX. *Coast of part of Louisiana and coast of Texas.*—FIELD-WORK.—To measure a primary base-line; to continue the triangulation and topography of *Madre Lagoon* from *Corpus Christi Bay* southward; to complete the hydrography of *Aransas, Copano*, and *Espiritu Santo Bays;* to continue the off-shore hydrography, and to make the requisite tidal observations. OFFICE WORK.—To make the office computations; to complete the engraving of coast chart No. 107, (*Matagorda and Lavaca Bays;*) to continue the drawing and engraving of Nos. 108 and 100, *Gulf coast from Matagorda to Corpus Christi Bay;* to engrave the re-survey of *Galveston Entrance;* and to continue the drawing and commence the engraving of general chart No. XVI, *Gulf coast from Galveston to the Rio Grande*, will require.......... 30,000

Total for Atlantic coast and Gulf of Mexico.......... 370,000

The estimates for the *Pacific coast* of the United States are intended to provide for the following progress in the survey:

SECTION X. *Coast of California.*—FIELD-WORK.—To make the required observations for latitude, longitude, and azimuth, at stations of the primary triangulation, and to make magnetic observations; to connect the islands of *Santa Cruz, Santa Rosa*, and

San Miguel with the coast triangulation; to execute the topography of the same, and continue the topography of the coast from *Buenaventura* to *Santa Barbara*, and from *Point Conception* northward; to continue the off-shore hydrography of the coast of *California*, and the tidal observations. OFFICE-WORK.—To make the computations of observations, and to continue the drawing and engraving of the maps and charts made in the field; also for the operations in

SECTION XI. *Coast of Oregon and of Washington Territory.*—FIELD-WORK.—To continue the astronomical and magnetic observations in this section, and the triangulation, topography, and hydrography in *Washington Sound* and in *Puget Sound;* to continue the survey of the mouth of the *Columbia River;* and to make such special surveys as may be called for by public interests on the coast of *Oregon* and *Washington Territory;* and to continue the drawing and engraving dependent on the field-work and hydrography, will require.. $175,000

For publishing the observations made in the progress of the survey of the coast of the United States, per act of March 3, 1843.. 5,000

For repairs and maintenance of the complement of vessels used in the survey of the coast, including the purchase of new vessels to replace those too old for repairs, per act of March 2, 1853.. 60,000

For pay and rations of engineers for the steamers used in the hydrography of the coast survey, no longer supplied by the Navy Department, per act of June 12, 1858..... 5,000

The annexed table shows, in parallel columns, the appropriations made for the fiscal year 1868–'69, and the estimates now submitted for the fiscal year 1869–'70:

Objects.	Estimated for 1869–'70.	Appropriated for 1868–'69.
For survey of the Atlantic and Gulf coasts of the United States, including compensation of civilians engaged in the work, per act of March 3, 1843	$370,000	$275,000
For continuing the survey of the Pacific coast of the United States, including compensation of civilians engaged in the work, per act of September 30, 1850	175,000	130,000
For publishing the observations made in the progress of the survey of the coast of the United States, including compensation of civilians engaged in the work, per act of March 3, 1843.	5,000	5,000
For the repairs and maintenance of the complement of vessels used in the survey of the coast, per act of March 2, 1853	60,000	30,000
For pay and rations of engineers for the steamers used in the hydrography of the coast survey, no longer supplied by the Navy Department, per act of June 12, 1858	5,000	10,000
Total	615,000	450,000

ASTRONOMY.

The discussion of the results for our astronomical latitudes, depending upon observations with the zenith-telescope, has pointed to defective catalogue-places of a number of stars, which it was desirable to replace by better determinations. In September, 1866, the United States Naval Observatory was requested to re-observe the north polar distances of about three hundred and forty-eight stars thus selected from our results as unsatisfactory. This request being kindly acceded to in March last, Commodore B. F. Sands, U. S. N., Superintendent of the Naval Observatory, communicated the results of the observations made with the transit-circle of the Observatory. All were referred to the epoch 1870.0, and the transcript was accompanied by the usual constants to facilitate the reduction from mean to apparent places. On an average, each of the stars was observed on three nights. The incorporation of these observations in our discussions has materially improved the results for latitude.

In this connection, I would also allude to a series of observations undertaken by Professor Joseph Winlock, director of the Cambridge (Harvard College) Observatory, for improving the list of assigned star-places. The list of so-called "time-stars" of the American Ephemeris and Nautical Almanac has proved to be not large enough to meet all the wants of the Coast Survey in telegraphic and other longitude determinations. A list of five hundred and forty-five stars between 30° and 70° north declination, at intervals of about two minutes in right ascension, was therefore selected, and the separate stars were observed with the meridian-circle of the observatory. In this service about five thousand observations were recorded. In reducing these, the places in the American Ephemeris were used as standard places.

It is proposed to continue observations on the stars in the list referred to, together with those in the standard catalogue, by means of the improved apparatus of the Cambridge Observatory, for absolute determinations of both right ascension and declination, in order to furnish a catalogue to serve for longitude and latitude determinations. The value of such a list for latitude determinations will be considerable, the fact being that the method almost exclusively used upon the survey is that which employs the zenith telescope, the results of which depend directly upon the assigned north polar distances of the stars used for latitude.

In order to fill the intervals of the time-star list heretofore used, Assistant George Davidson has compiled a supplementary list. These, combined with the entries in the previous list, give an average interval of less than five minutes, and thus much time is saved in making any given series of observations. The star-positions inserted by Mr. Davidson depend upon about twelve thousand observations.

MAGNETISM.

At the magnetic station in Washington, Assistant Charles A. Schott has made uninterrupted monthly observations since January, 1867. Professor Winlock, at the Cambridge Observatory, has coöperated in this branch of inquiry. During a period of about a year, closing in May last, regular determinations were made of the magnetic declination, dip, and intensity, on three days at the middle of each month. These observations included the daily range of the declination, and furnished results for the annual and secular changes, in addition to the determination of the mean amounts. Unfortunately the Cambridge series was interrupted by the resignation of the observer, Mr. Searle. The Washington series will be steadily continued by Assistant Schott.

TIDES.

The general theory of the tides has been intrusted to William Ferrel, esq., whose profound and elaborate researches have advanced the solution quite beyond his predecessors. He has been especially successful in the introduction of terms depending upon friction. These have materially modified the theoretical results and have brought them into closer harmony with observation.

A full series of nineteen years of tidal observations having been completed at the Boston dry-dock, Mr. Ferrel undertook a thorough discussion of them to obtain the constants which theory leaves to be determined from observation for each port, and which are necessary for completing the formulæ, and for preparing tables of prediction.

The method adopted in obtaining the first averages of groups of observations, contained within certain small limits of the arguments, is the same as Lubbock's in the discussion of the London and Liverpool observations, with, however, some important modifications. Circular arguments have been used, because of several advantages, instead of parallaxes and declinations. Longitudes were substituted for declinations, and the moon's and sun's anomalies for parallaxes. From the average results of as many observations as could be conveniently included in the same group, used as normals, the compound tide-wave, by means of various combinations of these normals, has been resolved into its principal components, and the constants belonging to each have been obtained by the method of least squares. The object has not been to obtain directly all the constants belonging to all the terms of any theoretical development, but rather to obtain a few fundamental constants, upon which all the others depend, and from which they can be obtained by the aid of theory. The discussion, however, has not been confined to the least number which theory requires to be

determined from observation; but the constants of a great number of inequalities, in addition to the number which theory requires, have been obtained for the sake of comparison with theory, though it has not been thought necessary to undertake to get out the constants of all the inequalities belonging to any theoretical development. Most of the constants would be unimportant practically, and it would require a vast amount of labor to obtain them from a discussion of the observations, with as much accuracy as they would have when derived theoretically from the fundamental constants by means of only a tolerably accurate theory.

Although circular arguments have been used in the discussion for the sake of advantages which they afford, both practically and for theoretical purposes, yet in the final forms in which the results are put for practical purposes, parallaxes and declinations are used as arguments, since, by such means, the number of arguments is much lessened, and the computation of the predictions of the tides much shortened.

Mr. Ferrel's report, giving a detailed account of the discussion, with full explanations of the method adopted, and containing all the results, together with various comparisons of them with theory, and with corresponding results found for European ports, and also auxiliary tables to be used for the purpose of prediction, is contained in the Appendix, (No. 5.) Not the least interesting of the particulars contained in that paper is the determination of the moon's mass from the relation of the constants obtained as results of the discussion.

LIGHT-HOUSE BOARD.

The intimacy of relation between the developments of the survey and the light-house service has been maintained as heretofore. The Board is thus furnished with data proving the necessity, in certain cases, of changing the position of aids to navigation, and the changes when made are marked on our charts.

In the frequent questions referred to me for consideration concerning the expediency of dispensing with lights or buoys in some places, and of establishing aids to navigation in others, I have had the able and practical advice of the hydrographic inspector of the Coast Survey, Captain Patterson. Some of these questions take rise in local interest only; but all such are, though in a restricted sense, important. In serving the ends alluded to, regard is not withdrawn from the requisites for general navigation, both objects being taken into view jointly when questions arise. The effort will be to systematize, so that a given number of lights may be as effective as possible.

Among the questions of the present year are some concerning lights on the lakes, and a system for the navigation of Chesapeake Bay, to which special attention was given by my colleague on the committee, General Hartman Bache. Besides the coast-lights pertaining to our own waters, attention has also been given to a proposal, communicated through the Department of State, from the commission of light-houses in Spain, for changing the character of the lights near the Straits of Gibraltar; and also to the system of lights proposed by a mixed commission of American and British authorities for the waters of the empire of Japan.

The various inquiries in regard to lights or buoys on the coast and Lakes of the United States connect with the following localities: Half-Way Rock, (Casco Bay;) Pollock Rip, and Shovelfull Shoal, off Monomoy, Massachusetts; Black Rock Harbor, Connecticut; Cliffwood, New Jersey; Peconic Bay, (Long Island, New York;) the lights of Hudson River above and below Albany; the lights of Chesapeake Bay; two sites in the Rappahannock River; Elizabeth River, Virginia; Bodie's Island; Laurel Point, (Albemarle Sound,) and Cape Fear Entrance, North Carolina; Charleston Bar, South Carolina; Fernandina Bar, Florida; the Florida Reefs; Cape San Blas; Pensacola Entrance; Horn Island and Deer Island, (Mississippi Sound;) Matagorda Entrance, Texas; the lights of Lake Champlain; Oswego, New York; Lake Muskegon, North Bay and Bayley's Harbor, Wisconsin; Beaver Bay, (Lake Superior;) Yaquina Bay and Columbia River, Oregon; and the lights requisite for the coast of Alaska.

OBITUARIES.

The past year has been marked by the death of several whose experience, gained in many years of service, was of great value to the Coast Survey.

Assistant Samuel A. Gilbert died at St. Paul, Minnesota, on the 9th of June. He was brigadier

general by brevet, for active and meritorious services in the field during the recent war; and, as a civilian, was one of the most experienced of the assistants in triangulation and topography. The resolutions passed at a meeting of his associates, a few days after his decease, well express the sterling qualities of the man, as evinced within my own knowledge during the short period of my personal acquaintance with him. In the hope of recovering from the effect of hardships undergone in the military service, Assistant Gilbert left his home and his interesting family at Zanesville, Ohio, and dwelt during the greater part of a year at St. Paul. The cessation from active duty brought some measure of personal comfort, but failed to restore strength to his powerful frame and constitution, which finally wasted in consumption.

At a meeting of the assistants in the Coast Survey, present in Washington, on the 19th of June, 1868, the following resolutions were adopted:

"Whereas information has reached us of the death, at St. Paul, Minnesota, on the 9th instant, of our friend and associate, Brevet Brigadier General Samuel A. Gilbert, assistant in the Coast Survey:

"*Resolved*, That the officers of the Coast Survey learn with profound grief and sensibility of the removal from among them, by death, of one whose high qualities had impressed themselves on all who became associated with him, and whom they equally loved and respected.

"*Resolved*, That they recognized in their late associate the possession of those eminent abilities which are sure to lead to distinction, whether displayed in scientific pursuits or in military life. He possessed sound discretion and judgment, combined with vigor and energy in action. Setting his aims high, he was only satisfied when he attained his own ideal. He combined in an eminent degree gentleness with courage, modesty with knowledge, and self-control with enthusiasm. He gave his services as a military officer to the country during the late war, with the same ardor and vigorous ability which had marked his civil career, and won merited distinction.

"*Resolved*, That the Superintendent of the Coast Survey be respectfully requested to cause a copy of these resolutions to be placed upon the records of the Coast Survey, in token of our appreciation of the merits of our late valued associate, and to communicate these proceedings to his family."

Sub-Assistant Clarence Fendall died in active service at Norfolk, Virginia, on the 18th of September, being at the time of his last illness in command of the schooner Hassler, and of a hydrographic party. He was favorably known among his associates in the work by his amiable disposition, and, to those with whom he was assigned to coöperate, by constitutional activity, industry, and commendable zeal in the progress of any work given into his charge. Among the assistants whose services were recognized as useful in furthering military and naval operations during the late war, none was more conspicuous than Mr. Fendall. His services as topographer, during the siege of Vicksburg, were repeatedly recognized by Admiral Porter. While in that service Mr. Fendall contracted a form of disease that afterward became chronic, and thus his death was hastened.

Mr. Edward Wharton, who had been for a long period attached to the office in Washington, died suddenly at Baltimore, on the 15th of January. In the general oversight of work in the engraving division, and previously in the discharge of clerical duties connected with that branch of the office, he was conscientious and methodical. Mr. Wharton had won general esteem by his gentleness and urbanity.

The faithful watchman at the Coast Survey Office, W. P. Patterson, whose honesty and vigilance were much relied on by my predecessor during the eventful year 1861, died, after a short illness, on the 23d of September.

PART II.

In the following notices only the essential facts connected with each survey will be given. The notices will be arranged as heretofore in geographical order, beginning with field-work on the coast of Maine, and terminating, for the Atlantic and Gulf coast, with mention of work done on the coast of Texas. Passing to the Pacific coast the notices will be arranged differently, the most southern site of work being named first, and the others in geographical order going northward and terminating in Washington Territory.

In order to bring into more effective relation the triangulation, and the other branches of the work which depend upon it, the charge of details bearing upon local and secondary triangulation has been committed to Assistant Richard D. Cutts. Among these details are comprised exactness of result in providing for topographical work or hydrography; the proper connection of local work with the primary triangulation; the preservation of station-marks; and such personal oversight in the field as will secure unity and consistency in the character of the triangulation. This work has been pushed in five different localities in Section I, for the purpose of supplying data for the prompt and successful advance of the topography and hydrography. Part of the results obtained make provision for the progress of those branches of the service next year. Appendix No. 1 shows the number of triangulation and other parties that have worked in each of the coast sections, and the order in which the sites of work are named in that list is conformable with the arrangement of the detailed notices which will be entered upon presently.

Much of the topography being prospectively called for by the condition, at the opening of the season, of the drawings and engravings of adjacent parts, the services of Assistant H. L. Whiting have been continued, as well in regard to such additional details, and in the study of limits for new sites of work, as in suggestions for securing uniformity in topographical method and style, by personal intercourse with the plane-table parties.

As in former years, the care and outfit, and all that pertains to the vessels used in the field-work and hydrography, have been under the charge of Captain C. P. Patterson, the hydrographic inspector. In addition to this important routine, and to the office details connected with hydrographic work, Captain Patterson has given constant attention to the movements of the parties employed in sounding, and to means of securing the utmost use of the data yielded by field-work.

The field-parties, whose operations will now be recited, have already experienced the advantage to be derived from such a special study of separate and yet dependent details as that just alluded to. The duties of superintendence have been thus much facilitated by the comprehensive review which can be so readily had in conference with three of the most experienced assistants. I would here bear testimony to their steady devotion to the interests of the survey.

Similar advantages are looked for in the prosecution of future surveys on the western coast. Assistant George Davidson sailed in November, and is now at San Francisco. His knowledge of the state of the work on the Pacific coast, and of the prospective requirements, will be available in conducting the operations of the coming year.

SECTION I.

ATLANTIC COAST OF MAINE, NEW HAMPSHIRE, AND MASSACHUSETTS, AND OF RHODE ISLAND AS FAR SOUTH AS POINT JUDITH.—(SKETCHES NOS. 1 AND 2.)

Triangulation of the Fox Islands and Isle au Haut, (*Penobscot Bay, Maine.*)—To provide for the continuance of plane-table work on the islands lying in Penobscot Bay. Assistant G. A. Fairfield commenced on the 30th of July to determine the requisite points. Starting from known stations, one of which is the primary point on Isle au Haut, a triangulation was extended westward to include Vinal Haven and the islands in its vicinity, on which the topographical party of Assistant Dorr was about to commence work. The operations of Assistant Fairfield furnish the data needful for the finished survey of most of the islands at the entrance of Penobscot Bay. His party

passed to and fro in a small vessel hired for the purpose at Rockland. Field-work was continued until the 13th of October. The statistics are as follows:

Signals erected	32
Stations occupied	12
Points determined	29
Angles measured	108
Number of observations	1,538

Assistant Fairfield was aided by Mr. F. W. Perkins.

This party is now about to resume duty in the triangulation work of Section IV.

Topography of the Fox Islands.—In continuation of the work which was done last season on the north side of the Thoroughfare Passage through the Fox Islands in Penobscot Bay, Assistant F. W. Dorr took up the topography of Vinal Haven on the 1st of August. Two plane-tables were employed, one being kept in use by the aid, Mr. H. G. Ogden, during the entire working season. Points having been furnished by Assistant Fairfield, Mr. Dorr prosecuted the detailed survey of the northern and northeastern part of Vinal Haven, including also Widow's Island at the eastern entrance of the Thoroughfare, and Stimpson's, Colderwood's, and Babbidge Islands, which separate the passage into two channels called respectively the Main Thoroughfare and Little Thoroughfare. The sheet which represents these details was completed on the 14th of October in the field. As soon after as practicable, it was inked by Mr. Dorr and sent to the office. Mr. Joseph Hergesheimer served as aid in the field and in office-work.

Mr. Ogden, working from his camp on Leadbetter's Island, made the survey of the western side of Vinal Haven and of the numerous islands and exposed rocks in its vicinity. Most of the islands, like Vinal Haven itself, are immense granite rocks, scantily covered with a soil which sustains some trees and vegetation. "The most westerly limit of the sheet is Medric Rock, of about fifteen feet elevation, and surrounded by several ledges. Between it and the principal islands are many small islands and ledges, making these waters almost impassable for vessels."

In reference to the smaller and less frequently used passages through the Fox Islands, Mr. Ogden says: "What is called 'The Reach' is a narrow passage between Green's Island and Vinal Haven. This is used by small vessels bound from Carber's Harbor to Rockland and up the Penobscot, but it is narrow, and several ledges in it make it a dangerous passage for strangers. The same may be said generally of the channels between the islands. Old Harbor, at the west end of 'The Reach,' though small, affords a good shelter in all winds. Leadbetter's Narrows are much used, but there is a sunken ledge nearly in the middle. The most remarkable body of water is the 'Basin,' a bight in the western side of Vinal Haven. Of its two entrances, which are a mile apart, the southern one is a mere drain at high water. The northern entrance is passable for small vessels at high water; but the opening being scarcely twenty meters wide, the water runs as in a sluice, and it is only with great difficulty that boats can be pulled against the current."

The plane-table sheet of Mr. Ogden was completed on the 7th of November. It includes the sites of many granite quarries that are worked on Vinal Haven and in its vicinity.

Assistant Dorr furnished for the use of the hydrographic party tracings from his sheet of work, showing the shore-line of the Thoroughfare and its approaches. The statistics of topographical work are as follows:

Shore-line and outline of ledges, (miles)	150
Streams traced on islands, (miles)	31
Roads, (miles)	51½
Area of topography, (square miles)	48

The sheet returned by Mr. Ogden is so completely studded with islands, ledges, and outlying rocks that its area, as topography, of necessity includes the water-passages between the numerous obstacles.

Assistant Dorr passed the early part of the working season in Section IV, and Mr. Ogden in Section VIII. They are now making preparation for different sites of work on the Atlantic coast.

Hydrography of Penobscot Bay, Maine.—The hydrography of Penobscot Bay has been extended

by soundings made by the party of Sub-Assistant Charles Junken, between the 23d of July and the 20th of September. These connect with the work of last year and continue the hydrography eastward to Seal Island Rock. (See Sketch No. 1.) All the most dangerous rocks and ledges falling within the limits of the working-sheet of this season were developed by the soundings. A few yet remain, but less in importance, to be determined in character and position. Among those already on the hydrographic sheet are Foster's Ledge near Matinicus Island; Bantom Ledge and two others near Ragged Island; the South Breaker, off Matinicus Light; a ledge near the Inner and one near the Outer Black Ledge; Harbor Ledge, at the entrance to Matinicus Harbor; and a ledge near the north point of No Man's Land. Many others in the immediate vicinity of the islands at the southwest entrance to Penobscot Bay appear on the hydrographic sheet.

This work was done with the steamer Endeavor. Sub-Assistant Junken was aided by Messrs. L. B. Wright and G. W. Bissell. A summary is appended, showing the statistics of hydrography:

Miles run in sounding	627
Angles measured	6,156
Number of soundings	8,661

The remainder of the working season in this section was employed in service that will be mentioned under the next head.

Hydrography of Fox Island Thoroughfare, (Penobscot Bay.)—For this work the party of Sub-Assistant Junken was transferred from the entrance of the bay. The sounding of the thoroughfare was completed on the 7th of November, and includes the approaches from the east and west, and the vicinity of each of the numerous known rocks and ledges, as Dobbin Rock, which is exactly in the channel of the thoroughfare off Iron Point; a rock between the "Sugar Loaves" and the "Dumplings;" Stimpson's Ledge, and others near Channel Rock, Standpoint Ledge, and Babbidge's Island. The chart resulting from this survey has been plotted and is now in the office. The general statistics concerning it are as follows:

Miles run in sounding	352
Angles measured	4,897
Number of soundings	21,566

The two sheets turned in by Sub-Assistant Junken comprise an aggregate area of one hundred and six square miles. The previous work of the party will be alluded to under the head of Section V.

Topography of Tennant's Harbor and vicinity, Maine.—At the end of July, Assistant W. H. Dennis took up topographical work on the west side of the entrance to Penobscot Bay. The sheet first completed contains the survey of Seal Harbor, Tennant's Harbor, and Mosquito Harbor, all of which are used as harbors of refuge. The first two of the harbors named are of importance in other respects. Mr. Dennis represented, on this and on an adjoining plane-table sheet, all the ledges covered at high water that fell within the limits of his survey.

Field-work was continued until the 13th of November, at which time progress had been made on a sheet joining with the one completed earlier in the season. The second sheet contains the shore-line and a considerable portion of the detailed survey of the vicinity of South Thomaston.

Until the middle of September, Assistant Dennis was aided in field-work by Mr. F. H. Agnew. The following is a summary of the statistics:

Shore line surveyed, (miles)	72
Roads, (miles)	35
Area of topography, (square miles)	21

Mr. Dennis has now resumed topographical work in Section V.

Topography of Medomak River, Maine.—The shore-line having been previously traced, Sub-Assistant Charles Hosmer commenced the detailed survey of the shores of the Medomak on the 28th of July and completed that work by the 12th of September. As usual, a margin varying in width from one-half to one mile is represented in detail. Mr. Hosmer continued in the field until the 2d

of November, prosecuting in the interval the topographical survey of the west side of George's River below Thomaston. The aggregate statistics of his work are as follows:

Shore line surveyed, (miles)	34
Roads, (miles)	70
Area of topography, (square miles)	21½

Mr. O. H. Tittmann served as aid in this party.

After inking and depositing his plane-table sheets at the office, Sub-Assistant Hosmer made preparation to resume topographical duty, in which he had been previously engaged in Section V.

Hydrography of Muscongus Bay, Maine.—The work outstanding at the opening of the present season in Muscongus Bay has been completed by a party working under the direction of Sub-Assistant R. E. Halter, with the schooner Bailey and the steam-launch Sagadahoc. The space sounded out is comprised between Pemaquid Point and Allen's Island, and from Round Pond to a point near the mouth of Friendship River. Mr. Halter also revised several sheets of hydrography previously done, joining to the eastward and westward with his own work of this season. Soundings were commenced on the 24th of July, and were concluded on the 19th of October. In the progress of the work a ledge was developed at the entrance of Pemaquid New Harbor, which, though small, is resorted to in bad weather by coasters of the larger class as a place of refuge. The ledge being dangerous, the recommendation of Sub-Assistant Halter, that it should be marked by a buoy or spindle, was transmitted to the Light-House Board early in August.

Sub-Assistant W. W. Harding was attached to this party, but was transferred to Section III in September to conduct the hydrographic work which was under the charge of Sub-Assistant Fendall at the time of his decease. Mr. W. I. Vinal aided Mr. Halter in Muscongus Bay until the close of the season. The following is a summary of the statistics of work:

Miles run in sounding	642
Angles measured	5,578
Number of soundings	26,320

The hydrographic party erected forty-nine signals and recorded about fifteen hundred observations on the rise and fall of tides.

Early in the surveying year, Mr. Halter was engaged in Section IX. Arrangements for service during the winter being completed, he is about to take up hydrographic work on the coast of Georgia.

Triangulation of the Kennebec River, Maine.—On the 20th of July, Assistant S. C. McCorkle commenced the triangulation of the Kennebec, by occupying, on Merrymeeting Bay, stations that had been determined in conducting the general work along the coast of Maine in previous seasons. Along the shores of the Kennebec twenty-eight signals were erected between Merrymeeting Bay and Augusta. The work thus added is shown in a general way on Sketch No. 1.

Between Richmond and Gardiner, where the banks of the river are heavily wooded, it was found necessary to lessen the length of triangle sides, but in all other places the work was made conformable to requisites for the first order of river triangulation. Full provision has thus been made for the topographical survey between Bath and the head of navigation.

Mr. Frederick Stoever served as temporary aid in the party of Assistant McCorkle. Field-work was closed on the 25th of September, with the following results in statistics:

Signals erected	28
Objects observed on	44
Angles measured	165
Number of observations	4,440

Earlier in the working season, Mr. McCorkle had been engaged in Section VII, and he was subsequently employed on the shores of Narraganset Bay.

Hydrography.—By the party of Sub-Assistant J. S. Bradford, working with the schooner Dana, such revision and supplementary soundings have been made as were found needful between Pemaquid Point and Casco Entrance. In the Sheepscot river some additional soundings required for the completion of the chart were made above the bridge at Wiscasset.

Damiscove Harbor, on the island of Damiscove, was sounded out. In Sagadahoc Bay the Long Island Narrows were sounded, as were also the passages by Salter Island and Stage Island. Additional soundings were made in the bay near the entrance of Sheepscot River. These include the vicinity of Sloop Ledge, on which Mr. Bradford found as little as six feet of water. He developed in this neighborhood the Little River Ledges, finding shoal spots of two, four, and seven feet, and one rock six feet in diameter, which is dry at low water.

In the vicinity of the Kennebec the positions were determined of Seal Rock, near Parker's Head; Lee's Island Rock; a shoal near Pettis Rocks, with twelve feet of water on it; and Ram Island Rock. Soundings were made, and the position was determined, of Lethgrow's Rock, with seven feet of water near Fiddler's Reach. Winnegance Creek was sounded by the boats of the Dana, and a ledge in four feet water was sounded in the Kennebec near Bath.

In the approaches to the Kennebec, Mr. Bradford examined near the Heron Islands the rock known as "Bold Dick," and made additional soundings around the Heron and Fox Islands. Jackknife Ledge was found to have eight feet at mean low water, where six feet only had been reported. The passage was sounded between Salter's Island and the Whale's Back, and some additional lines of soundings were run in the neighborhood of Gilbert's Head.

The passage between Cape Small Point and Glover's Rock was sounded, as also that between Bald Head and Bald Head Ledge, including the ledge itself, as far as practicable. This ledge is bare at low tide, and the water breaks in the calmest weather. Lumbo's Ledge (Casco Bay) was examined, and no depth was found of less than seventeen feet at mean low water. Mr. Bradford found and developed a shoal in seven fathoms water northeast of Lumbo's Ledge.

Half-Way Rock, (Casco Bay.)—Sub-Assistant Bradford sounded the vicinity of this rock from the water-line to a depth of ten fathoms. On the shoal north of Half-Way Rock he found a depth of eleven feet at mean low water, on a rock so small that it was struck several times with the lead before the depth could be determined.

Early in December, 1867, Sub-Assistant C. H. Boyd made a plane-table survey of Half-Way Rock, and in forwarding his sketch reported as follows: "The rock is unstratified, indurated slate, similar to that which forms the coast-line in the vicinity. Its highest point above the high-water line is thirteen feet, and is quite small."

In the course of the working season in this section, beginning in July and closing at the end of October, Sub-Assistant Bradford determined and plotted the positions of eighteen ledges and rocks. The general hydrographic statistics of the work are:

Angles measured	434
Number of soundings	8,583

Mr. G. C. Schaeffer, jr., served as aid in the hydrographic party. Sub-Assistant Bradford had been previously engaged in Section IV.

Topography of New Meadows River, Maine.—Assistant A. W. Longfellow took the field on the 6th of July, and continued at work with the plane-table until the 24th of October. The detailed survey made during that interval embraces the shores of Winnegance Bay and the lower shores of New Meadows River, or from Phippsburg Basin upward to the Three Islands, and westward to Simpson's Gurnet, through which the tide-waters connect with those of Harpswell Sound. Within the limits of the plane-table sheet are included the towns of Phippsburg, West Bath, Brunswick, and Harpswell, the last named being the north and east portion of Great Island, or Sebaskahegan. The topography is intricate and difficult, from the rocky, broken, and wooded character of the ground. Numerous heights were measured by vertical angles on the alidade, in tracing the contours, but, where practicable, the elevations were determined by direct measurement. One hundred and sixteen miles of contour-lines were traced, and seven miles of roads, within an area of seven square miles. Assistant Longfellow used the schooner Meredith in this service.

Special survey in Portland Harbor, Maine.—At the request of the city authorities of Portland, a minute survey has been made of the vicinity of Munjoy Hill. Assistant J. A. Sullivan organized a party for this work, and commenced operations on the 26th of June. After making the requisite triangulations, series of levels were taken to establish accurate bench-marks upon the ground which was to be surveyed, and the marks, when set, were referred to the permanent tidal bench-

mark made in a previous year in the harbor. The survey of Munjoy Hill with the plane-table was commenced by Assistant H. L. Whiting, who delineated most of the shore-line, and determined many of the more prominent objects. Mr. A. Lindenkohl continued and completed the detailed survey of the hill. Along the shore-line, plane-table stations were made at intervals of a hundred and fifty feet, and stakes were ranged from them upon the adjacent flats to the opposite side of the channel, for hydrographic purposes. Soundings were taken upon the lines thus traced out, and also upon lines at equal intervals at right angles to them. The hill was surveyed so as to give means for a complete delineation of the irregularities of the surface. All the field expenses incurred were, at the instance of General Francis Fessenden, defrayed by the city, the authorities having acted upon suggestions made in his capacity as one of the aldermen, by which the survey was inaugurated.

The hydrography adjacent to Munjoy Hill was executed in the most thorough manner by Sub-Assistant Horace Anderson. Mr. J. N. McClintock aided in the field-work. The statistics are as follows:

Shore-line traced, (miles)	3
Hill curves, contour, (miles)	33
Streets, (miles)	$7\frac{1}{4}$
Angles for sounding	780
Number of soundings	10,443

Assistant Sullivan founded the part of the survey here alluded to on sixteen points, determined by his triangulation at the outset. The topographical survey was brought to a close on the 1st of October, but, the city authorities having made formal provision for extending the limits of the work next year, Mr. Sullivan remained in service until the 24th of October. Thirty additional points were determined by over two thousand observations with the theodolite, so that the plane-table work of the additional area can be taken up in the spring of next year without delay. The transfer of data from the field-sheets, and the drawing of a comprehensive map for the city on a scale of $\frac{1}{1200}$, are now in progress.

In November, Assistant Sullivan engaged in triangulation work in Section II. Sub-Assistant Anderson and Mr. McClintock at the same time took up duty in Section IX.

On the occasion of an official visit, I examined at Portland the results of the field-work then in progress, and was strongly impressed by its thoroughness. For purposes of practical utility, no means short of the geodetic process would present the details of surface with the requisite accuracy. At the invitation of the city authorities, the hydrographic inspector visited the harbor, and conferred personally in regard to the extension of the survey in the coming season.

Triangulation of Saco Bay, Maine.—Between Richmond Island and Wells Village, a triangulation has been made by Sub-Assistant Charles Ferguson. This is to serve as a basis for the plane-table survey, which will include about twenty-four miles of the sea-coast of Maine. The work was taken up on the 15th of July and concluded in the middle of October. The difficulties, which presented at an early period of the survey in conducting a triangulation for topographical purposes, are but slightly lessened, much timber that hinders the view still remaining in the vicinity of Biddeford and Saco. Between Wells and Saco a stretch of about twelve miles is thus covered, without having any considerable elevations near the coast-line for proper positions in the triangulation. Observing from scaffolds and other expedients were in such cases employed by Mr. Ferguson. The results of his work furnish points for two large-sized plane-table sheets. A summary of the statistics of triangulation is appended:

Stations occupied	12
Number of observations	2,098
Area of triangulation, (square miles)	120

In November, special application having been made for the services of a member of the Coast Survey for practical developments of ground in Arkansas, Sub-Assistant Ferguson was authorized to make the surveys needed in advance.

Triangulation, topography, and hydrography of Cape Cod Peninsula, Massachusetts.—The outstanding work on the peninsula of Cape Cod has been completed by the assignment in the summer of

several parties to work jointly. Of these, one conducted by Sub-Assistant C. H. Boyd took the field on the 1st of August, and continued until the 10th of November. Between those dates Mr. Boyd determined by triangulation the points required for the topographical parties of Assistant Adams and Assistant West, and for the plane-table work which was subsequently done, under his own direction, by Sub-Assistant H. W. Bache. The triangulation included the towns of Dennis, Brewster, Orleans, Harwich, and Chatham. The position of the new light-house on Billingsgate Shoal was also determined. In prosecuting the work, Mr. Boyd recognized and marked anew five of the stations occupied some years ago as points of reference for the coast hydrography. The general statistics of the triangulation are as follows:

Stations occupied	19
Points determined	30
Angles measured	123
Number of observations	1,854

Points sufficient for plane-table work having been determined by the 1st of September, Sub-Assistant Bache was placed in charge of a detached party to prosecute the survey in the vicinity of Chatham. The limits of his topographical sheet are Monomoy and Pleasant Bay. At the place last named, it joins with a sheet of Sub-Assistant Boyd, and is thus in connection with work done by the other two parties on the peninsula. The two sheets returned by Messrs. Boyd and Bache comprise the following, in statistics:

Shore line, (miles)	30
Roads, (miles)	17
Area of topography, (square miles)	12

The plane-table sheet of Sub-Assistant Boyd was executed in October.

Early in September, Mr. Boyd took up the hydrography of Pleasant Bay, including also, in the progress of the work, Chatham Harbor and Bar. A tide-gauge was established by bolting a graduated staff to a large boulder on the beach, and a daily record of its readings was kept for a month. In October two other gauges were put in operation, one near Chatham Bar and the other in the most distant part of the bay. The survey of Chatham Bar, and that of the vicinity of the harbor, illustrate the constant degradation, change of outline, and shift of sand, to which this part of the peninsula of Cape Cod is subject. A synopsis of the statistics of work is appended:

Miles run in sounding	86
Sextant angles	1,278
Casts of the lead	8,616

Sub-Assistant Boyd was aided in field operations by Mr. J. G. Spaulding.

Mr. Boyd is about to resume in Section VIII a survey in which he was engaged during the early part of the present surveying year.

Assistant Hull Adams completed, in August, the topography of four and a half miles of the south shore of Cape Cod Bay. The detailed survey was carried inland as far as the old road between Orleans and Brewster, and was made to include also the course of the railroad in that vicinity. To the eastward and westward the plane-table sheet here referred to joins with work completed by other parties.

On the eastern side of Cape Cod Peninsula, Assistant Adams and his aid, Mr. H. L. Marindin, joined with previous work at Nausett Entrance, and extended the topography southward along the outer coast as far as the opening into Pleasant Bay. Inland the survey embraces the shores of that bay and its branches, the limit of topography being the road that passes from Chatham to Orleans. The islands in the bay, the coves, and other features of natural detail, are represented on the plane-table sheet.

On the north side of the peninsula, or shore of Cape Cod Bay, the surface exhibits a series of conical and rounded elevations with corresponding depressions. These are formed by sand-drift, and in some instances rise to more than a hundred feet in height. The same features mark the outer coast of the peninsula; but these, by the action of the tide, are subject to rapid changes by

degradation. The aggregate of work in the two localities is expressed in the following summary of statistics:

Shore line of main and islands, (miles)	22
Outline of marsh, ponds, (miles)	31
Roads, (miles)	61
Area of topography, (square miles)	29½

The work here alluded to was concluded at the end of October. It joins at its southern limit with topography done by Sub-Assistant Boyd.

Assistant P. C. F. West took up the topography of the south shore of Cape Cod Bay at Brewster early in August, joining in that vicinity with the plane-table work by Assistant Adams. Going westward, the small harbors of Sursuit and Nobscusset were surveyed, and the general features of the shore of the bay to a point beyond North Dennis, where Mr. West joined with work done in a previous season. Although several ships of large size have been built at Sursuit, that harbor, and the one adjoining, are used now mostly for laying up fishing-vessels during winter. The points needful for the topographical surveys done this season by Assistant West and Assistant Adams were furnished by the triangulation of Sub-Assistant Boyd. Mr. West makes the following return in statistics:

Shore line, (miles)	8
Creeks and marsh line, (miles)	30
Roads, (miles)	48
Area of topography, (square miles)	12

This work completes the detailed survey of the shores of the Cape Cod Peninsula. On the occasion of two visits in the course of the season, I have been strongly impressed with the accuracy of the topographical details.

Resurvey of Monomoy Point, Massachusetts.—Assistant West, after completing his plane-table work near Brewster, proceeded early in November to trace the outline of Monomoy Point, for comparison with the survey previously made. The result shows that great changes have taken place, as might be expected from the character of the formation. The character of these changes is important, in view of the fact that as many as four hundred sail of vessels have been counted in a single view from the point.

Assistant West is now preparing to enter upon topographical duty in Section V.

Hydrography near Monomoy Point, Massachusetts.—At the request of Commodore George S. Blake, U. S. N., light-house inspector of the second district, Sub-Assistant F. F. Nes was detailed in August to aid in making soundings, with a view to develop the general character of the changes that have occurred in depth in that vicinity.

About eleven hundred casts of the lead made on the Shovelful Shoal and on the broken parts of Pollock Rip were deemed sufficient by the inspector for the purpose in view. On the completion of this service, Mr. Nes joined the party of Assistant Gerdes in New York Harbor. His previous duty afloat will be mentioned under the head of Section IX.

Hen and Chickens light-ship.—After completing the hydrographic survey of Narraganset Bay, to be noticed presently, Assistant F. P. Webber reached Buzzard's Bay on the 16th of October, and determined the position at that time of the light-ship on the Hen and Chickens. The notes necessary for marking the position on sailing-charts are now on file in the office.

Triangulation of Wickford Bay, Rhode Island.—The additional points found necessary to the further advance of the detailed survey of the shores of Narraganset Bay were determined by Assistant S. C. McCorkle, in September and October. Stations on Prudence Island and Conanicut Island were connected by triangulation with others on the shores of Wickford Bay. Assistant Webber, in charge of the hydrography, coöperated with Mr. McCorkle in setting the requisite signals. The statistics are as follows:

Signals erected	7
Stations occupied	6
Angles measured	120
Number of observations	780

Mr. F. Stoever aided in making the triangulation.

Assistant McCorkle has since resumed field duty in Section VII.

Topography of Narraganset Bay, Rhode Island.—The detailed topographical survey has been prosecuted by Assistant A. M. Harrison in the vicinity of Wickford Harbor, the sheet projected for that part of the shore of Narraganset Bay, including also Warwick Neck, Greenwich Bay, Brush Neck, and the lower parts of Apponaug and Potowamut Rivers. This sheet was completed early in October. Work was then taken up on a plane-table sheet to include the survey westward of Greenwich Bay. Mr. Harrison had well advanced toward completion in this vicinity late in November, when he was taken seriously ill. He had previously added some details to the plane-table survey of the neighborhood of Warren. Sub-Assistant H. M. DeWees aided in the field and office work, after joining the party early in August. The plane-table statistics are as follows:

Shore line surveyed, (miles)	39
Creeks, &c., (miles)	19
Roads, (miles)	58
Area in topography, (square miles)	19

Hydrography of Narraganset Bay, Rhode Island.—The hydrography of this important bay has been completed. Assistant F. P. Webber resumed work on the 18th of July, setting up as soon as practicable tide-gauges and erecting the signals needful. The western part of the bay between the north end of Canonicut Island and the north end of Hope Island was then sounded. In August work was taken up and prosecuted to completion between Quonset Point and Dutch Island. In the latter part of the season terminating on the 12th of October, Mr. Webber made soundings between the south end of Dutch Island and the entrance of the bay, and there joined with the coast hydrography which had been completed in a former year. The work was done altogether with boats belonging to the schooner Joseph Henry, the condition of the vessel being such as to call for general repairs, which were deferred until the close of the season in this section. The vessel was laid up at Wickford in October.

Assistant Webber was efficiently aided by Acting Ensign Frederick Ilsley, U. S. N., and by Messrs. F. D. Granger, A. P. Barnard, and W. T. Angell. The statistics of work are as follows:

Miles run in sounding	250
Angles measured	2,568
Number of soundings	20,516

After making the determination in Buzzard's Bay, previously referred to, Assistant Webber proceeded to Section VIII to resume hydrographic duty.

Tidal observations.—It became necessary, in 1867, to arrange for a new permanent tidal station on the coast of Maine, owing to the extension of the survey to the eastward, and as Owl's Head, in Penobscot Entrance, seemed so be a suitable site, a self-registering gauge was put up there by Mr. A. C. Mitchell. In the charge of Mr. G. D. Wooster, observations were recorded from July 17 until December 8, 1867, when they were discontinued in consequence of severe frosts and storms. The series has since been resumed at a more favorable station, at North Harbor, on one of the Fox Islands, in Penobscot Bay.

The self-registering tide-gauge at the Charlestown navy yard has performed well, but during the severe weather of last winter it frequently stopped, and some of the tides were thus lost from the record. Mr. H. Howland, the observer, records also the meteorological observations.

In the office some new devices have been suggested, and will be tried, with a view to the continuance of tidal observations at exposed places during winter.

The data derived from the permanent tidal stations are of direct avail in the location of forts, light-houses, or other public works, and in the means adopted for improving harbors, for general investigations relating to the laws of the tides, and for connecting and systematizing the results found by hydrographic parties at numerous stations more or less distant from the permanent stations.

SECTION II.

ATLANTIC COAST OF CONNECTICUT, NEW YORK, AND NEW JERSEY, INCLUDING PENNSYLVANIA AND DELAWARE, AS FAR SOUTH AS CAPE HENLOPEN.—(SKETCHES NOS. 6 AND 7.)

Primary stations.—An important duty connected with the field-work of the Coast Survey is the preservation of the stations of the primary triangulation. All are carefully marked when they are occupied, but the changes consequent upon the rapid growth of our sea-board cities make it a matter of no little difficulty to maintain undisturbed the marks set in their vicinity. In the course of the present season, Assistant John Farley visited the primary stations Round Hill and Bald Hill, in Connecticut; Hempstead Hill and West Base, on Long Island; Buttermilk Hill, near Tarrytown, New York; Weasel Mountain, Mount Rose, Mount Holly, and Stony Hill, in New Jersey; Yard Station and Willow Grove, in Pennsylvania; and Meeting-House Station, in the State of Delaware. Principio Station, near the head of Chesapeake Bay, has been visited and secured by Assistant Richard D. Cutts.

The elaborate report made by Assistant Farley at the end of the season is accompanied by descriptions and drawings of the sites as they now are, and by notes showing what changes have occurred in each locality since the stations were occupied. Where necessary, Mr. Farley made additional marks and measurements, and furnished notes for reference.

Special survey at Hell Gate.—In July and August, at the request of the engineer officer in charge, Assistant F. H. Gerdes made special observations in the vicinity of Hell Gate for the purpose of procuring such data as would be needed for the engineering operations then contemplated. Careful levelings were made of the shore of East River in the neighborhood of Hell Gate, the tides were observed, and the velocity of the current was determined at a number of stations. Transcripts of all the records of observations were furnished to the engineer officers.

At three of the tidal stations occupied by Mr. Gerdes, observations were recorded every ten minutes, day and night, for about twenty days, and similar notes were taken at three other gauges for four days. The tidal elevations were referred to permanent bench-marks.

Soundings in New York Harbor.—In September, Assistant Gerdes resurveyed, for the use of the pilot commissioners, a portion of the harbor between New York City and Staten Island, the object being to determine the character of reported changes in the main channel. Sub-Assistant F. F. Nes aided in this service, and plotted the chart which resulted from the soundings.

Mr. Gerdes, in the preceding June, examined, with reference to changes that have occurred in the channel of the Hudson, all the auxiliary lights between the cities of Hudson and Albany. His elaborate report on the subject was referred for the information of the Light-House Board.

Survey at Rondout, Hudson River, New York.—This special survey was undertaken with a view to the development of facilities at the mouth of Rondout Creek for water transportation between Rondout and New York City. Assistant Gerdes commenced the field-work in September, and prosecuted the topography and hydrography steadily until the 17th of November, when the survey was completed. The resulting maps were then taken in hand, and will occupy the party until after the close of the year. Mr. Gerdes was aided by Sub-Assistant Nes after the middle of September. The detailed survey at Rondout embraced such portions of the topography as would enter of necessity into the consideration of plans for improving the navigation of the creek. A summary of the statistics of work is here given, as stated in the report from the field:

Shore-line surveyed, (miles)	15½
Roads, (miles)	18
Area of topography, (square miles)	4
Miles run in sounding	61
Angles measured	1,515
Number of soundings	9,509

These soundings were made on over three hundred different lines, the courses and directions of which were all carefully determined from shore stations.

During the year 1868, an aggregate of about three million tonnage crossed the bar in passing into Hudson River from Rondout Harbor.

Triangulation, coast of New Jersey.—The connection of the New Jersey coast triangulation, from the line Chapel Hill–Mount Mitchell, in the vicinity of Sandy Hook, with the main series crossing New York Bay, has been very nearly completed within the past season, and would have been entirely finished but for the serious illness of Assistant W. S. Edwards, who had the work in charge. In the month of October of last year, observations were completed at five stations. Operations were then suspended for the season, but were resumed in June of the present year. In the two months named 8 stations were occupied, and 55 angles were determined by 1,159 observations. In the progress of the work the new beacons in the lower bay were determined and a junction was effected with the main series of triangles. A few more observations are still required at one of the stations, a delay due to the difficulty of seeing through the thick atmosphere which generally hangs over the city of New York. The observations needful could not be obtained before Mr. Edwards became too unwell to continue in the field.

Topography near Barnegat Bay, New Jersey.—The topography of the coast of New Jersey was resumed by Assistant C. M. Bache at the end of July in the vicinity of Squan River. After joining properly with a previous sheet of work, the plane-table survey was extended southward along the sea-coast to the head of Barnegat Bay. In its progress several miles in length of the upper part of the bay were included, and also parts of Beaver Dam Creek and Metiticonk River that flow into the bay.

Assistant Bache was aided in the field by Mr. Eugene Ellicott. This party had passed the first part of the working year in Section V. The following are the statistics of the work done on the coast of New Jersey:

Shore-line of sea, river, &c., (miles)	66
Roads, (miles)	51
Area of topography, (square miles)	16

Field-work was continued until the 3d of November. Mr. Bache is now engaged in inking his topographical sheets.

Tidal observations.—The series of tidal observations in New York Harbor has been continued by Mr. R. T. Bassett with the self-registering gauge on Governor's Island, and with the box-gauge at the dock of the Hamilton-avenue ferry in Brooklyn. These observations, by the continuity of the series, have furnished data for many important and costly works, both public and private, in and around the harbor and its connected waters. No important improvement likely to be affected by the tides has been undertaken in recent years without application to the Coast Survey Office. The observations made in July and August at several stations around Hell Gate by Assistant F. H. Gerdes were for the purpose of furnishing data needful in the proposed improvement of that channel.

In November and December, 1867, Mr. A. C. Mitchell established bench-marks at several stations along the coast of New Jersey as points for referring the rise and fall of tide to the mean level of the sea.

SECTION III.

COAST OF DELAWARE AND MARYLAND, AND OF VIRGINIA AS FAR SOUTH AS CAPE HENRY.—(SKETCH NO. 8.)

Primary triangulation.—In order to avoid natural difficulties presented by the coast features in the extension of the primary triangulation southward of Chesapeake Bay, a series of main triangles has been projected to rest upon the first range of hills back from and parallel to the coast-line, with a view to connect as early as possible with the base-lines measured on the ocean-beach in North Carolina and South Carolina. The expediency of the proposed operation was determined by a general reconnaissance made in November and December of last year by Assistant C. O. Boutelle.

Primary stations near Washington City are already directly connected with the Kent Island

base, and with the great chain of primary triangles between Chesapeake Bay and the northeastern boundary of the United States at the Bay of Fundy.

The general aspect of the country around Washington is that of a high table-land, gradually increasing in elevation as it recedes from tide-water. In the progress of time, valleys and river-courses have been formed in this table-land by erosion, but no hills, in the usual meaning of the term, exist. The reconnaissance developed that the crests or summits of the table-land on each side of the Potomac River were near Spencerville, in Maryland, and near Vienna, in Virginia, and that by the use of artificial elevations for the theodolite a single quadrilateral of good shape would carry the triangulation from two of the primary stations already determined to a line commanding the Blue Ridge from Maryland Heights to Manassas.

After his return from Section V, in June last, Mr. Boutelle selected sites for stations, in accordance with his previous general reconnaissance, to connect with the chain of great triangles already completed upon the line Hill–Webb. As soon as practicable signals and observing tripods were erected for occupying the two stations just named. Sugar Loaf Mountain, near the mouth of Monocacy and twenty-eight miles northwest of Washington, is visible from that city, and is so prominent and commanding from every point of the horizon that it was necessarily taken as one of the objects to connect upon. A very careful reconnaissance fixed the crest of the table-land and consequent site of the station directly connecting Sugar Loaf with the base Hill–Webb upon the farm of Mr. Asa R. Stabler, near Spencerville. The point selected is 570 feet above the sea. As it fell in the midst of a highly cultivated country, Assistant Boutelle put up an observing tripod fifty feet high, to look over the surrounding shrubbery and to avoid the cutting of fruit-trees. An avenue for sight required, however, to be opened in the direction to Webb Station.

The fourth point of the quadrilateral was found at Peach Grove on the Loudoun and Alexandria Turnpike, thirteen miles from Washington. A line from Sugar Loaf to this point commands the Blue Ridge from Harper's Ferry to below Front Royal. Peach Grove Station is 520 feet above sea.

At Hill Station Mr. Boutelle found undisturbed the mark that had been placed in 1850, when the station was occupied by Professor Bache. It is 279 feet above sea, but required the erection of a tripod fifty-one feet high in order to bring Sugar Loaf Mountain into view over the intervening ridges in Montgomery County, Maryland.

Mr. Boutelle erected signals of the usual form at Webb, Hill, Sugar Loaf Mountain, Peach Grove, Soper, and Causten Stations, (Sketch No. 8;) and in September began the measurement of angles at Webb Station, aided by Mr. F. H. Agnew. The thirty-inch theodolite was used. Hill Station was occupied between the 9th of October and the 17th of November. At both stations the magnetic declination and intensity were observed, and aggregates of 879 observations for horizontal angles and 254 observations for vertical angles were recorded.

The office discussion of the observations made at Hill Station with the large theodolite, elevated over fifty feet, will have special interest, connected with the progress of similar work over the wooded region of the southern coast. On closing the observations at that station, Assistant Boutelle transferred his party to Seation Station, in Washington, where he is now engaged.

Topography and hydrography of the Chesapeake Estuaries.—A party in charge of Sub-Assistant J. W. Donn has been in active service during the entire year in mapping and sounding the principal estuaries of the Chesapeake. Plane-table work was continued through the winter on Yeocomico River at such intervals of weather as admitted of field duty. In March the party was provided for hydrographic service, and by the close of the first week in July the surveys were complete of the Yeocomico and Coan Rivers, Virginia; the St. George's and Wicomico Rivers, Maryland; Currioman and Nomini Bays, Virginia, with Mattox and Nomini Creeks, and the head of Lower Machodoc River. Within the same period the topography was completed of Britton's Bay and St. Clement's Bay, and the shores of the Potomac from Piney Point to Cob Point, on the Maryland side, and from Mattox Creek to Lower Machodoc River, on the Virginia side. Additions were made to the survey of the river between Ragged Point and Smith's Point. After some needful repairs on the schooner Bowditch, the party resumed work early in August on the branches of Mobjack Bay. The shores were surveyed and the channels were sounded of the East, North, Ware, and Severn Rivers.

This service occupied the party until the close of October. The following are aggregates of the statistics of plane-table work and hydrography:

Shore-line surveyed, (miles)	315
Creeks, (miles)	60
Area of topography, (square miles)	36
Miles run in sounding	662
Angles measured	1,869
Number of soundings	35,450

Mr. R. B. Palfrey served as aid during part of the present season. Sub-Assistant Donn is still engaged in the joint work of topography and hydrography. Before closing this section mention will be made of a development in Rappahannock River by the same party.

On the eastern side of the Chesapeake a number of the estuaries, passed by when the general hydrography of the bay was executed, have been sounded out by a party in the schooner Hassler. Previous to his death, which occurred at Norfolk in September, Sub-Assistant Clarence Fendall, in conducting the operations of the party, had completed work in Hunger Creek, and had sounded the Naswaddox, the Nandua, the Craddock, and the Occohannock, having commenced field operations in April. In July he transferred his party to the western side of the bay, and was about to resume hydrographic duty in the branches of Mobjack Bay, when seized with the illness of which he died. The party was continued in service under the charge of the aid, Mr. Arthur F. Pearl, and during September and October soundings were completed in Back River and in Poquosin River. At present and during the coming winter the operations will be conducted by Sub-Assistant W. W. Harding. Mr. Pearl makes the following return in statistics for the entire working season:

Miles run in sounding	505
Angles measured	3,378
Number of soundings	50,287

Both parties, while working in the Chesapeake, observed the tides at permanent stations, and also at temporary stations, in each of the several places in which soundings were made.

Bowler's Rock and Corner Rock, Rappahannock River, Virginia.—The character of these two shoal places in the Rappahannock River, with reference to light-house purposes, was carefully developed in December, 1867, by Sub-Assistant Donn. A sheet on a large scale, containing soundings, tidal notes, &c., was turned in at the office in January, together with sketches showing the horizontal contours and profiles of several longitudinal sections of both of the rocks. In connection with soundings, the tides were observed and recorded for fifteen days. Respecting the first-named impediment in the navigation of the river, Mr. Donn reports:

"*Bowler's Rock* is simply a bed of dark-blue, tough mud, mixed with oyster-shells and overlaid by loose shells and growing oysters. The upper crust of this irregular ledge, irregular because crossed at nearly right angles to the axis of the tidal currents by narrow, deep channels, is compact and hard; but, with little exertion, an iron-pointed pole was passed through the crust of twelve inches thickness into the mud below, and down to a depth of ten feet from the hard surface. *Corner Rock* is composed of sand and broken shells, and covered with growing oyster beds. No force at hand would suffice to push the pole to a greater depth than eighteen inches. On this shoal the least depth at mean low water was found to be five and a half feet."

Hydrographic examination in Elizabeth River, Virginia.—On the 27th of August a careful survey was made by Acting Master Platt with his party in the surveying steamer Bibb, of the vicinity of the wreck of the iron-clad rebel steamer Merrimac. This was done in compliance with a request from Commodore Kelty, commandant of the United States navy yard at Norfolk. The wreck encroaches on the channel of the river, and parts of it are dangerous to passing vessels. Acting Master Platt furnished to the commandant a chart, showing distinctly what portions of the wreck should be removed to make the navigation of the channel safe for vessels passing to and from Norfolk. In the next section, and under Section VI, mention will be made of the general service of this party.

Tidal observations.—Mr. E. F. Krebs has continued in charge of the self-registering tide-gauge at Old Point Comfort, Virginia. This series is now very satisfactorily maintained, and, being one of the longest we have, it will soon be sufficiently extended to warrant discussion for general purposes.

SECTION IV.

COAST OF NORTH CAROLINA AS FAR SOUTH AS CAPE FEAR.—(SKETCH No. 14.)

Triangulation south of Cape Henry, Virginia.—In my report for 1867, a statement in detail was presented of the progress made by the party charged with the final connection of the primary triangulation of Chesapeake Bay with the main series, stretching to the northward from the base-line on Bodie's Island, in North Carolina. Since that date the operations of the party of Assistant Richard D. Cutts have been necessarily confined to a reconnaissance for continuing the direct measurement of the coast to the southward, and for the purpose of ascertaining the lines upon which the connection could be made and verified.

Early in November, Mr. F. W. Perkins, the aid in the party, under the direction of Assistant Cutts, proceeded to Norfolk, and thence to the outer coast; and, after examining the stations of the previous season, laid off on the ocean-beach, and to the southward of the terminus of the last line measured, a base three miles and three-quarters in length, and so arranged as to escape, as far as it was possible to do so, the sand knolls on the one side, and on the other the wrecks and the interval between the ordinary high and low water marks. Starting from this line, a scheme of triangulation, composed principally of quadrilaterals, was planned to extend over the old tertiary work, and to terminate down the coast on a comparatively long line common to both series, and to include an intermediate check. The signals of the two points nearest to the base were erected; duplicate descriptions of the stations were made; and a report giving the details of the reconnaissance, the extent of the cutting that will be necessary, and the special outfit required by the character of the coast, for the execution of the scheme. This preliminary service was completed by the 1st of December. The base will be measured and the triangulation extended from it in the course of the coming season.

Hydrography of the coast of Virginia and North Carolina.—The off-shore soundings south of Cape Henry were taken up at the limit of previous work, on the 22d of July, by Acting Master Robert Platt, U. S. N., assistant Coast Survey, with a party in the steamer Bibb. From False Cape the soundings were extended southward to "Kill Devil Hill," on the coast of North Carolina, and seaward about fifteen miles. Within that space 7,965 soundings were made on lines in which positions were determined by 1,738 angles. The area sounded being unprotected from all winds to the eastward of north or south, the hydrography of this vicinity proved to be very difficult. Boats from the steamer could land, for the purpose of putting up signals as ranges in sounding, only by passing through a heavy rolling surf. They were frequently filled with water, and in other instances all hands were thrown into the surf. To these unusual hazards were superadded the impossibility of continuing operations during easterly winds by reason of the heavy swell thus occasioned, and the necessity in many cases of making for a harbor during long-continued squalls. The hydrography immediately below Cape Henry having shown the existence of shoal spots or uneven bottom, Acting Master Platt adopted every means for securing accuracy, with a view of developing the exact nature of the bottom within the limits of the work of this year. In the vicinity of False Cape, where the bottom appeared to be somewhat uneven, the soundings were made numerous, but no spots were found so shoal as to obstruct the navigation of coasting vessels. Immediately off the False Cape, shoal spots, with only fifteen or sixteen feet water, occur as far out as three miles or more from the beach.

In October the steamer Bibb sailed from Hampton Roads for the purpose of sounding on the Wimble Shoals, but in a heavy gale the vessel was somewhat damaged, and one of the boats was lost before getting into Beaufort, North Carolina. A strong easterly gale, encountered soon after coming out, deferred the intended survey.

The Bibb has since refitted at Norfolk, and is now in service near the Florida Reef.

Triangulation of Pamplico Sound, North Carolina.—Assistant G. A. Fairfield, having completed the triangulation of the Neuse, resumed work at the entrance of that river in the middle of January. After restoring one of the main signals that had been cut down and carried away since the work closed in the previous season, the triangulation was extended northward along the western shore of Pamplico Sound. Bay River is included in the scheme of triangles measured this

year, and stations were selected to extend the triangulation to the mouth of Pamplico River. The work done is in complete connection with two of the primary stations in the sound, and with the completed triangulation of the Neuse River.

Assistant Fairfield was effectively aided by Mr. F. W. Perkins. The points needed by Assistant Dorr, for the topography of Turnagain Bay, and by Sub-Assistant Bradford, in the hydrography, were furnished by this party.

Field-work was closed at the end of April. The schooner Dana was then dispatched by Assistant Fairfield, for Portland, Maine. Under the head of Section I, mention has been made of the work subsequently done by the party of Mr. Fairfield. The statistics of the triangulation in Pamplico Sound are as follows:

Signals erected	17
Points determined	19
Stations occupied	16
Angles measured	79
Number of observations	1,750

Field-work is about to be resumed by the parties in Pamplico Sound.

Topography of Neuse River, North Carolina.—This work has been completed. Assistant F. W. Dorr took up the two final sheets toward the end of January, having previously organized a party for service in the steamer Hetzel. One of the sheets shows the plane-table features of the north bank from Smith's Point downward to the entrance of the river into Pamplico Sound; the other sheet contains the detailed survey of the south side below Cedar Point. All the affluents and estuaries of the lower part of the river are represented, the principal being South River, Broad Creek, and Turnagain Bay.

Sub-Assistant H. W. Bache was attached to this party. After closing work the Hetzel was returned and laid up at Newbern. The following synopsis shows the statistics of work:

Shore line of river and creeks, (miles)	160
Shore of streams, (miles)	60
Roads, (miles)	53
Area of plane-table sheets, (square miles)	119

The survey was completed on the 4th of May.

Assistant Dorr passed the working season at the North in Section I. Sub-Assistant Bache was attached to another party in the same quarter of the coast.

Hydrography of the Neuse River, North Carolina.—This work has been completed by soundings made between the 1st of December, 1867, and the end of May, of the present year, by Sub-Assistant J. S. Bradford, with a party in the schooner Arago. The hydrography was resumed at Wilkinson's Point, and terminated at the mouth of the river at a point about forty-two miles below Newbern.

Unfavorable weather prevented the extension of the soundings from the river entrance toward Hatteras Inlet. In general the months most suitable, in respect of calm weather, for hydrographic operations in Pamplico Sound, are June and July, when the heat and liability to sickness are unfortunately the greatest.

Messrs. F. D. Granger and G. C. Schaeffer, jr., aided efficiently in the hydrographic survey, the first-named taking the active charge of the party during an extended period of illness which disabled Sub-Assistant Bradford. Special mention is also made in the field report of the earnest and effective coöperation of Acting Master James H. Porter, who had charge of the schooner Arago, and of the essential service rendered by Mr. Albert Bayles, the engineer of the steam-launch used in the hydrography.

The statistics of the work done are as follows:

Miles run in sounding	549
Angles determined	2,055
Number of soundings	73,755

In July Sub-Assistant Bradford took up hydrographic duty, which has been mentioned under the head of Section I.

SECTION V.

COAST OF SOUTH CAROLINA AND GEORGIA AS FAR SOUTH AS ST. MARY'S RIVER.—(SKETCH No. 15.)

Primary triangulation near Port Royal, South Carolina.—The primary triangulation of the coast of South Carolina was resumed in February last by Assistant C. O. Boutelle. At the outbreak of the rebellion the work rested at stations on the north side of Port Royal Sound. Other stations in connection with them were selected by Mr. Boutelle, on Hilton Head Island, and on other Sea Islands intervening between it and the Savannah River, making the primary triangulation complete between Charleston and the boundary of Georgia. Mr. Boutelle reports that the general level of the country covered by his work does not vary more than twelve feet. Hence artificial elevations are requisite to overcome natural curvature, and to carry the line of sight at its middle point above the disturbed stratum of air, near the surface of the ground. For observing on signals ten miles distant or more, Mr. Boutelle has used his theodolite on structures having forty-five feet elevation. Much difficulty, nevertheless, has to be overcome in clearing the lines of sight, the stations not being generally intervisible because of intervening trees. The secondary triangulation having passed over the same ground, the process for establishing a primary station is to select one approximately and connect it with the secondary work. Means being thus afforded for computing the direction and distance to a previously occupied primary station, the direction is carefully laid off and a point is found in the line. Here a portable transit-instrument is set up, and the line is traced throughout its entire length, or until the signal at the approximate primary station becomes visible. If no insuperable obstacle is encountered, as a house or other permanent structure, the line is adopted and opened by cutting away all overhanging trees for a width of ten feet on each side of the transit-line.

The subsequent field service of Assistant Boutelle has been mentioned under the head of Section III. He was aided on the coast of South Carolina by Sub-Assistant Charles Ferguson and Mr. J. N. McClintock.

Topography of Beaufort River and Chowan River, South Carolina.—The detailed survey needed to complete the field-work below Beaufort, South Carolina, was taken up on the 30th of January by Sub-Assistant Charles Hosmer. Assistant Whiting having made a special reconnaissance of this quarter in the previous season, the work done was conducted under his supervision. Mr. Hosmer filled in all the details of Parry Island, and mapped the western side of St. Helena Island along the Chowan River. His sheet represents also the features of the neck of land between Beaufort River and Battery Creek, and those of Cane Island, Cat Island, Gibbs's, Distant, and part of Ladies' Island. Nearly the entire course of Jericho Creek was included in the plane-table work of this season.

After the middle of April, Mr. J. N. McClintock aided in field-work, having been detached from the party of Assistant Boutelle. An accident to the steam-launch Ossabaw, which was used by the party of Sub-Assistant Hosmer, necessitated the close of work early in May. The following are the statistics:

Shore-line surveyed, (miles)	125
Roads, (miles)	45
Area of topography, (square miles)	21½

While the plane-table work was in progress near Jericho Creek, over two thousand casts of the lead were made. The characteristic soundings derived from them appear on the sheet turned in by Mr. Hosmer.

Topography of St. Catharine's Sound, Georgia.—The whole of Ossabaw Island had been traced in outline, and part of the details of topography had been filled in, previous to the war. In February, the unsurveyed space, including the lower part of Ossabaw Island, was mapped by Assistant C. M. Bache, with a party in the schooner Bailey. Mr. Bache then proceeded to a site of work lower down on the coast of Georgia.

Topography of St. Andrew's Sound, Georgia.—This work was commenced in March, the party

of Assistant Bache having passed to it with the schooner Bailey, by the inside route from Ossabaw. During March and April the outside approaches to the entrance of the sound, and the shores of the rivers and creeks emptying into it, were traced, and the adjoining details were mapped with the plane-table.

Mr. Eugene Ellicott rendered good service as aid in the topographical party.

The following are statistics of the work done:

Inside shore-line traced, (miles)	115
Coast-line traced, (miles)	9½
Area of topography, (square miles)	54½

On the 3d of May, the schooner Bailey left Brunswick, Georgia, and on arrival was laid up at Portland, Maine.

Assistant Bache and Mr. Ellicott were, during the summer, employed in field-work in Section II.

Topography of Doboy Sound, Georgia.—The party of Assistant W. H. Dennis took up the detailed survey of Doboy Sound in the middle of January, using the schooner Caswell for the transportation of instruments and for quarters. After setting the requisite signal-poles, a junction was made with work done in a previous year by Assistant Longfellow on Blackbeard Island and Sapelo Island, (see Sketch No. 15,) and the topography of both of the islands was completed. In addition to the shores of the sound, Mr. Dennis traced and mapped the dependencies known as Duplin River, Darien River, North River, Back River, Connegan River, and on the north side of the sheet Mud River, by which there is water communication from Doboy Sound to Sapelo Sound. Cabrita Inlet, which borders the Government reservation of live-oak timber on Blackbeard Island, is also represented on the plane-table sheet of Assistant Dennis.

"Most of the firm land on Sapelo Island requires drainage for cultivation. There are some fine live-oak groves, considerable pine timber, and quite a number of fresh-water swamps. A large area of salt-marsh separates the island from the main-land, the distance being about five miles. This space is traversed in every direction by runs and creeks, the larger of which are navigable. The edge of the main-land is made quite irregular by long points of firm land extending into the marsh, and these being considered the most healthy locations are quite thickly settled."

In this survey Assistant Dennis was aided by Mr. J. G. Spaulding. The statistics of field-work are as follows:

Shore-line, navigable waters, (miles)	188
Shore-line, small creeks, (miles)	96
Roads, (miles)	52
Marsh outline	76
Area of plane-table sheet, (square miles)	81

The topography was closed on the 20th of May. After discharging the party the schooner Caswell was laid up at Darien. Mention of the subsequent occupation of Assistant Dennis has been made under Section I.

Hydrography of Doboy Sound, Georgia.—This hydrographic survey was commenced by Sub-Assistant Charles Junken on the 19th of February, with a party in the steamer Endeavor. Outside of the entrance a junction was formed with the soundings previously made in surveying the approaches to Sapelo Sound, and also with work done to the southward outside of Altamaha Sound. The hydrographic sheet of the season includes the bar and approaches, the inlet and Doboy Sound, Darien River to the town of Darien, the island passage through Mud River and Teakettle Creek, and all the estuaries connecting with Doboy Sound. The points requisite for the sounding lines were furnished by the topographical party of Assistant Dennis.

Sub-Assistant Junken was aided by Messrs. L. B. Wright and G. W. Bissell. The following is a synopsis from the hydrographic sheet:

Miles run in sounding	927
Angles determined	10,951
Number of casts of the lead	70,064

Forty signals were erected by the party in the Endeavor in prosecuting this survey. The soundings were completed on the 29th of May.

Mr. Junken was engaged with his party during the summer and autumn in work that has been reported under the head of Section I.

SECTION VI.

ATLANTIC COAST OF FLORIDA; THE REEFS AND KEYS, AND THE GULF COAST OF FLORIDA, AS FAR NORTH AS ST. JOSEPH'S BAY, NEAR TAMPA.—(SKETCH No. 16.)

Topography and hydrography of Barnes's Sound, Florida.—The survey of the peninsula of Florida in the immediate vicinity of Cape Sable has been well advanced by the party of Sub-Assistant C. T. Iardella working with the schooner Agassiz. Beginning near the cape, the plane-table survey was carried eastward and includes, besides the usual margin of the main land, all the outlying keys and patches in the vicinity of the shore or within the limits of the projected sheet. By means of sextant angles a subsidiary triangulation was made, sufficient for tracing the shore-line to about fifteen miles east and as far westward of Shark Point. One hundred and ten miles of shore-line were traced within an area of twenty square miles. The waters of the vicinity were also sounded by the party. In prosecuting this part of the work, fifty-three signals were erected and determined in position by sextant angles. The general particulars of the hydrography are as follows:

Miles run in sounding	138
Angles determined	112
Casts of the lead	5,107

The tides were recorded at three stations while the soundings were in progress.

The work in Barnes's Sound was continued until the middle of May.

Mr. H. L. Marindin aided in the topography and hydrography.

Hydrography near Florida Reef.—The hydrographic party under command of Acting Master Robert Platt, U. S. A., passed the latter part of the winter and the early part of spring in service with the steamer Bibb, in the vicinity of the Florida Reef. On the south side of the reef the curve of one hundred fathoms was determined from the Marquesas off to the southward and westward of the Tortugas. The banks existing in that quarter were sounded, and generally the seaward approaches to the Tortugas.

Lines of soundings were run between the Rebecca and Isaac Shoals and the Marquesas, and the channel between those shoals and the Tortugas was surveyed. In running the lines to the Marquesas, a number of shoal spots with only three and four fathoms were found by Acting Master Platt, directly in the channel hitherto supposed to be clear and to have from six to ten fathoms.

The great bank to the southward and westward of Loggerhead Key was thoroughly sounded out to a depth of thirty-five fathoms. No depth less than six fathoms was found in this survey. This bank is resorted to as a fishing-ground, the character of the bottom being generally coral rock. In furthering operations which will be alluded to presently, an aggregate of nearly fifteen hundred miles of lines of sounding were run at sea by the party in the steamer Bibb. Exclusive of these, the general statistics of the hydrographic work done in the section are as follows:

Miles run in rounding	783
Angles measured	2,655
Number of soundings	8,884

Acting Master Platt was aided by Messrs. Gershom Bradford and J. B. Adamson.

During the summer and autumn the party was steadily engaged in hydrographic work in Sections III and IV.

Assistant L. F. Pourtales accompanied the party in the steamer Bibb, and made investigations relative to the growth of coral, the formation of the reefs and keys of Florida, their liability to change, and the rate of such changes as have occurred. Important facts bearing upon some of

these questions were collected, and experiments were instituted to determine in future the time required for the growth of coral.

After the party was joined by Assistant Henry Mitchell, the Bibb proceeded to the Salt Key Bank to make soundings and current observations under his direction, across the St. Nicholas and Santaren Channels and across the Gulf Stream between Sombrero Light and the Double-Headed Shot Keys. Subsequently six lines of deep-sea soundings, accompanied by dredgings, were run normal to the Florida Reef between Sand Key and Sombrero. These developed the existence of a kind of submarine plateau, or gentle slope, with rocky bottom, forming a band parallel to the reef beyond the one-hundred-fathom line. As reported by Assistant Pourtales, this plateau is inhabited by a rich fauna of invertebrate animals, most of which are quite new to scientific investigators. Dredgings were made at depths of more than five hundred fathoms with ease and success. The report of Mr. Pourtales (Appendix No. 12) gives further details in regard to these operations. The interesting zoölogical results will be communicated, for the benefit of science, through another channel of publication.

Acting Master Platt facilitated, in every way within his power, the operations conducted by Assistants Pourtales and Mitchell.

SECTION VII.

GULF COAST OF WESTERN FLORIDA, AND OF ALABAMA EAST OF MOBILE BAY.—(SKETCH No. 17.)

Triangulation and topography of St. Joseph's Bay, (north,) Florida.—Assistant S. C. McCorkle resumed field-work early in January at Cape St. Blas with a party in the schooner Torrey. After perfecting a connection between stations selected near the cape, and others which he had previously occupied in St. Vincent Sound, a triangulation was carried northward quite through St. Joseph's Bay. The lines of this triangulation span the bay, stations on the main-land connecting by lines with four stations on the sand-spit that bounds the bay on the westward. In passing from St. Vincent Sound across the peninsula above Cape St. Blas, one of the lines of triangulation required opening through the woods in order to bring into view the station on Black's Island in St. Joseph's Bay. The statistics of the triangulation are as follows:

Signals erected	6
Stations occupied	10
Angles measured	46
Number of observations	2,580

During March and April immense fires prevailed in the woods, and the smoke, with the storms then frequent, much impeded the field-work.

As the work of triangulation advanced, the topographical survey of St. Joseph's Bay was pushed by Sub-Assistant H. M. De Wees. Eastward of Cape St. Blas the shore-line survey was joined with the plane-table work done in a former year, and northward of the cape Mr. De Wees traced the entire shore-line of St. Joseph's Bay. In order to facilitate future operations in hydrography, the positions were determined of a number of points, all of which are carefully marked on the plane-table sheet. The statistics reported by Sub-Assistant De Wees are as follows:

Shore line surveyed, (miles)	79
Roads, (miles)	10
Bayous, (miles)	11
Area of topography, (square miles)	20

Early in May, when the field-work was discontinued, the schooner Torrey was laid up near Apalachicola.

A base-line of verification being desirable midway between the bases at Cape Sable and Dauphin Island, the attention of Assistant McCorkle has been given to the selection of a proper site. It is believed that the immediate vicinity of Apalachicola affords conditions quite favorable for the intended measurement.

Gulf coast near Mobile Point.—The topographical survey of the coast between Pensacola and Mobile Point was completed during the summer of 1867 by Assistant J. G. Oltmanns, work being then joined at East Gulf-shore station with the former survey that had been extended eastward from Mobile Point. For a greater part of the distance a linear measurement was substituted for triangulation to avoid the expense of cutting lines through a dense forest that skirts the beach closely. The measurement was made with the subsidiary base-apparatus described in the Coast Survey Report for 1857. In following the changing direction of the beach, the unbroken lines averaged about a quarter of a mile in length. The angles between the several lines were carefully measured and the directions were, besides, carried forward by angles between intervisible stations of the measurement, about five miles apart. These operations, somewhat novel in their present application, were planned by Assistant J. E. Hilgard and have been executed under his immediate direction.

On reaching the field covered by the survey made some years previous, Assistant Oltmanns could find none of the stations that had been trigonometrically determined to the eastward of Fort Morgan, their sites having been destroyed either by the action of the sea or wind. Although the work done afforded a sufficient junction for the purposes of a chart, it was deemed important that it should be effected with the accuracy that pertains to triangulation, so that no link might be wanting hereafter in the measurement of the great arc of a parallel from the mouth of the St. John's (Florida) to Galveston, in Texas, which the survey of the Gulf coast incidentally accomplishes.

On resuming field-work in November, 1867, Mr. Oltmanns was directed to make a measurement similar to that before executed, between his terminal station and Fort Morgan, obtaining an azimuth at the former point and referring the direction of his measured line at Fort Morgan to some point in the triangulation of Mobile Bay. A search for the former stations showed that most of them were irrecoverable, having been washed away or wantonly destroyed. This led to an examination of the condition of the base-line on Dauphin Island, and no vestige of the carefully secured points of that line remained excepting the disturbed marks at the east end. Assistant Oltmanns thus reports: "I regret to say that beyond the already mentioned disturbed marks at the east end, no trace of any mark whatever could be recognized. The entire line was then carefully chained from the east end, and, at every point for a mile-stone or other mark mentioned in the superintendent's journal of the original measurement, close and diligent search was made by my entire party, but without being once rewarded with success. Neither the old disturbed monument at the west end, nor the screw-pile, nor the marble blocks and logs mentioned in reports on the line by Assistants Hilgard and Gerdes could be found, though the search for them was close and continued for three days."

Mr. Oltmanns subsequently made a resurvey of points of land and islands circumscribing Mobile Entrance in order to determine what changes have taken place, and what means may be required to secure the site of Sand Island light. The exact position of the old light on Sand Island, a former triangulation point, was recovered, and the connecting line, Fort Morgan–Sand Island Light, thus secured for the work recently done. The measurement of the beach is in connection with that line, and was continued as far as practicable with the funds available for the expenditures of the party. A few miles yet remain to be measured. During the present season Assistant Oltmanns was aided by Mr. F. H. Agnew.

SECTION VIII.

GULF COAST OF ALABAMA AND MISSISSIPPI, AND OF LOUISIANA AS FAR WEST AS VERMILION BAY.—(SKETCH No. 18.)

Triangulation and topography, Mississippi River, Louisiana.—Above the head of the passes the survey has been extended along the east bank of the Mississippi by the party of Sub-Assistant C. H. Boyd. The triangulation of this year includes Bird Island Sound, Grand Bay, and part of the western end of Isle au Breton Sound. Within the limits of triangulation the shore-lines of the river were traced, and a survey was made of the lagoons and bayous. In doing this the high

stage of water was a serious obstacle to steady work with the plane-table, the instrument being of necessity frequently set up in water two feet deep. The same cause impeded progress in the triangulation by making it difficult to gain firm positions for the theodolite. In most cases scaffolds with an elevation of twenty feet were required for the instrument, to enable the observer to see over the growth of reeds. In this way twenty-one positions were determined within an area of one hundred and thirty square miles. The statistics of triangulation are:

Stations occupied	11
Angles measured	70
Number of observations	702

The details shown on the two plane-table sheets comprise the following:

Outside shore-line, (miles)	103
Bayous, &c., (miles)	42
River-banks, (miles)	30

Field-work was commenced on the 1st of February, and closed on the 4th of May. The schooner James Hall was used in this survey.

Mr. H. G. Ogden efficiently aided in the triangulation and topography. The resulting topographical sheets have been inked by Mr. Boyd and deposited in the Office. Under Section I, notice has been taken of the subsequent operations of this party. Field-work will be continued in Isle au Breton Sound during the coming winter.

Hydrography of the Mississippi Delta.—A party in charge of Assistant F. P. Webber, with the schooner Varina and steam-launch Barataria, was detailed in January to complete the survey of the delta by sounding between the passes of the Mississippi. This duty was effected by the 4th of May. The work referred to includes Garden Island Bay, between Southeast Pass and South Pass; East Bay, between the latter and Southwest Pass; and West Bay, lying on the west side of the delta. East Bay having been partly sounded in 1867 by Assistant Gerdes, the work of this season was made continuous with the soundings given on his sheet of that quarter, and with others representing the hydrography of the passes and of the approaches to them. In connection with the soundings, Assistant Webber conducted tidal observations at Pilot Town (Southwest Pass) and at the light-house wharf in South Pass. The statistics of work are as follows:

Miles run in sounding	349
Angles	1,084
Number of soundings	27,481

Sub-Assistant Horace Anderson was attached to this party. Mr. A. P. Barnard served as aid. Assistant Webber acknowledges also the efficient services rendered by Mr. W. T. Angell, and by Acting Ensign E. Studley, jr., in prosecuting the hydrography, and the courtesy of Captain Freeman, of the Revenue Service, in giving tow with the cutter Wilderness, when it was desirable to transfer the schooner Varina, during a calm, to work at South Pass.

During several weeks in March the Varina and her crew were used by Assistant Dean in determining the position of the light-house at Last Island.

Assistant Webber passed the working season at the north in Section I.

Longitude.—In extending the system of observations by telegraph beyond New Orleans, a party was organized last winter under Assistant G. W. Dean, for making at Galveston, Texas, such determinations for longitude as have been made at various stations along the coast of the Atlantic and Gulf of Mexico in previous years.

The astronomical station occupied at New Orleans by Mr Dean in 1858 had been destroyed, but while engaged there he had established, and carefully marked, a meridian-line, in which the station was included. Granite posts set in that year to distinguish the line were easily found, and the copper bolts in them served to restore the line, and, of course, the position of the station in longitude. While a temporary observatory was being erected about forty feet due north of the station used in 1858, Assistand Edward Goodfellow put up a similar observatory in the public square of Galveston, near the Catholic cathedral. The subsequent operations, having in view the determination of the longitude of Galveston, will be stated under the head of Section IX. At New Orleans,

340 observations were made upon 38 zenith and circumpolar stars, with the 46-inch transit, C. S., No. 4, for determining the clock and instrumental corrections. Messrs. Dean and Goodfellow made the observations requisite at New Orleans for personal equation, in the month of February.

Mr. S. C. Chandler, jr., assisted in the longitude operations at this station, and remained in charge while Assistant Dean was absent on other duty in the section.

Ship Shoal light-house, Louisiana.—Near the close of February, Assistant Dean proceeded from New Orleans to Brashear City with two chronometers, and was there joined by Assistant Goodfellow with two other chronometers. All of them had been several times compared by telegraph with the astronomical clock at New Orleans, for determining the corrections and rates. Messrs. Dean and Goodfellow took steamer down the Atchafalaya, and at a point previously agreed upon were transferred to the Coast Survey schooner Varina, by which vessel they reached Last Island. There the requisite astronomical observations and other measurements were made for determining the latitude and longitude of Ship Shoal light-house. The chronometer corrections and rates at Last Island were determined by 18 transit observations upon 14 zenith and circumpolar stars, on two nights, and the astronomical station on the island was connected by triangulation with Ship Shoal light-house by means of a base of three lines, having a total length of two miles and three-quarters. The base was carefully measured with a twenty-meter chain.

When this service was complete, the schooner Varina was returned to the party of Assistant Webber. The work near Ship Shoal light-house was closed on the 14th of March.

SECTION IX.

GULF COAST OF LOUISIANA WEST OF VERMILION BAY, AND COAST OF TEXAS.—(SKETCH No. 19.)

Longitude of Galveston, Texas.—As stated in the preceding section of this report, the astronomical station at Galveston was located in the public square of the city. Assistant Goodfellow here made 179 observations upon 40 zenith and circumpolar stars, with transit No. 6, for clock and instrumental corrections. At favorable intervals between the 5th and 19th of February, clock comparisons were successfully made by telegraph on six nights, between Mr. Goodfellow at Galveston, and Assistant Dean at New Orleans. In connection with this work, the measurements necessary for referring the astronomical station to a station of the main triangulation, near Galveston, were made by Assistant Goodfellow, aided by Mr. F. Blake, jr.

Magnetic observations.—After completing the operations for longitude, Assistant Goodfellow and Mr. Blake crossed Galveston Bay to Dollar Point, and there made a series of magnetic determinations, three sets for the horizontal intensity and moment of inertia, observations on three days for dip, and eighty-four observations on two days for the magnetic declination.

Latitude of Lavaca, Texas.—In the month of April 186 observations were made by the party of Assistant Dean for latitude upon 35 sets of stars with the zenith telescope No. 5. The arc measure of the micrometer divisions was determined from 82 observations upon star 51 Cephei near its western elongation. For ascertaining the value of the level divisions, 60 observations were made upon the threads of a small theodolite which was adjusted to a sidereal focus.

Azimuth.—The true bearing of one of the lines of the triangulation near Lavaca was determined from 150 observations upon Polaris, near its western elongation, with a ten-inch Gambey theodolite. With the same instrument 105 measures were made of the angle between the elongation-mark and Sand Point signal. Astronomical time was obtained from 75 observations upon 19 zenith and circumpolar stars, with the twenty-four-inch transit No. 10.

Magnetic observations at Lavaca.—The declination was determined by 100 readings of the magnet scale on three days. Horizontal intensity and moment of inertia were ascertained by two complete series of experiments by deflections and vibrations on two days. The dip of the needle was found by three sets of observations repeated on three days.

Early in May Assistant Dean returned with his party to New Orleans, and from thence forwarded the instruments which had been in use in this section to the Coast Survey Office.

The results for longitude, latitude, azimuth, and magnetic elements were computed by the members of the party in the course of the summer. As heretofore, the use of the telegraph lines was freely accorded by the managers in the section. For important facilities Assistant Dean expresses his obligations to Colonel John Van Horn, general superintendent of the southern division; to Mr. D. Flanery, superintendent at New Orleans; and to Mr. D. P. Shepherd, superintendent of the lines in Texas. The kind action of the local officers had been previously sanctioned by the directors of the Western Union Telegraph Company.

Facilities were also furnished in the careful transportation of instruments by Captain J. N. Lewis and Captain J. J. Atkinson, of the Morgan Line of steamers at Brashear City.

Hydrography of Galveston Entrance, Texas.—Some additional data being requisite for the purposes of the Engineer Department, Sub-Assistant R. E. Halter made a special examination at Galveston Entrance in March and April. The shore-line was retraced at Fort Point and Pelican Spit, and borings were made in both places to determine the character of the deposit. At a number of stations across the entrance and inside of the harbor the direction and velocity of the current were observed. The information gathered at the request of Lieutenant W. S. Stanton, of the United States Corps of Engineers, and some additional soundings, were presented to that officer in the form of a chart for the uses of the Engineer Department.

Sub-Assistant Halter performed this service with the schooner M. L. Stevens, and was aided in hydrographic duty by Messrs. C. P. Dillaway and R. B. Palfrey. Mr. Halter subsequently conducted a party in Section I.

Hydrography of Matagorda and Lavaca Bays, Texas.—Previous to taking up the duty requested for the Engineer Department, as alluded to in the last notice, Sub-Assistant Halter had commenced the soundings requisite for completing the chart of Matagorda and Lavaca Bays. Two days were thus employed previous to the transfer of the hydrographic party to Galveston. The statistics of work done in Matagorda Bay are as follows:

Miles run in sounding	49
Angles measured	205
Number of soundings	4,962

Hydrography of Aransas Pass, Texas.—With a party in the schooner Peirce, Sub-Assistant F. F. Nes erected signals at the pass, and in Aransas Bay as far north as Mud Island. In the latter part of February soundings were made, completely developing the character of the entrance at that period. The bar is constantly shifting, but it is stated by the local pilots that a depth of eight feet can always be carried across at high tide.

While the party of Mr. Nes was engaged in Aransas Pass, six steamers were running regularly between Rockport and New Orleans. These carry principally live stock, but large quantities of beef, cured by infiltration and packed, are also sent eastward. Much of the produce exported from Corpus Christi, and merchandise and lumber received there in return, find way through Aransas Pass.

Sub-Assistant Nes was aided in this section by Sub-Assistant W. W. Harding and Mr. A. L. Ross. The statistics of work at Aransas Pass are as follows:

Miles run in sounding	76
Angles measured	498
Number of soundings	8,829

Hydrography of Corpus Christi Bay, Texas.—This work was taken up by Sub-Assistant Nes on the 3d of March, and was continued until the 23d of April. The vessel used by the party being in great need of repairs in order to be safe for the return to Galveston, Mr. Nes employed the crew in making such as were indispensable, there being at the time no ship-carpenters at Corpus Christi.

During the summer the hydrography done by the party in this section was plotted by Mr. Nes, and, as charts, turned in at the Office. A synopsis given on that of Corpus Christi Bay is as follows:

Miles run in sounding	578
Angles observed	1,430
Number of soundings	41,844

Sub-Assistant Nes passed the remainder of the season in duty afloat in Sections I and II. Mr. Harding was subsequently employed in Sections I and II. Both are now making arrangements for hydrographic work during the winter.

SECTION X.

PACIFIC COAST OF CALIFORNIA.—(SKETCH No. 23.)

Triangulation and topography on Santa Barbara Channel, California.—The survey of the shore of the Santa Barbara Channel has been advanced in both kinds of field-work by Assistant W. E. Greenwell. In the direction of Point Duma the secondary triangulation has been advanced, and seven additional stations have been occupied within limits covered by the topographical surveys of previous years. Mr. Greenwell took up plane-table work at Santa Barbara and extended it about seven miles along the sea-coast in the direction to San Buenaventura. The statistics are as follows:

Signals erected	7
Objects observed on	11
Number of observations	1,570
Shore-line surveyed, (miles)	7
Roads, (miles)	9½
Area of topography, (square miles)	9

The operations on the Santa Barbara Channel were much impeded by the undue fall of rain, which, during the wet season, made an aggregate of twenty-four inches, and by the fog and smoke that subsequently prevailed. In reference to the character of this part of the Pacific coast, Assistant Greenwell remarks: "Every little cove from Point Conception to San Buenaventura, a distance of ninety miles, will, when developed, give safe anchorage during eight months of the year; and with this facility to shipping the advance must be rapid in population and improvement. The climate is temperate, and the productiveness of the soil is probably unsurpassed in California. The vine, the fig, the olive, and the orange are found growing in perfection side by side in the same garden with the apple, peach, and pear, while the more essential productions, as maize, barley, and wheat, yield large returns along this entire coast."

Field operations were discontinued by Assistant Greenwell on the 10th of October.

Topography near San Francisco, California.—The topographical survey of the peninsula near San Francisco, at the request of the Engineer Department, was continued during the winter of 1867–'68 under the supervision of Assistant A. F. Rodgers, and was finally closed in the middle of January of the present year. The ground between School-House Station and Millbrae was mapped by Assistant C. Rockwell. After closing in the field, the details of the several plane-table sheets were combined by Assistant Rodgers into one large map for the use of the engineers. The contours being everywhere determined by means of the level, and the existing artificial details being filled in with the utmost accuracy, this sheet cannot fail to meet all the requirements of the service for defensive purposes.

Sub-Assistant G. Farquhar and Mr. A. W. Chase aided in the office-work connected with this survey. The last-named aid joined the party of Assistant Greenwell in May, but subsequently conducted a party for a local survey on the coast of Oregon. In June Mr. Farquhar was assigned to duty in the hydrographic party of Assistant Cordell. Assistant Rockwell, with his aid, Mr. L. A. Sengteller, proceeded to Astoria in May for plane-table work on the shores of the Columbia River.

Assistant A. F. Rodgers, after completing his sheets of the survey of the interior of the peninsula near San Francisco, traced the adjacent roads and other features so as to perfect a junction with the old sheets of the survey which had passed around the shore-line of the peninsula. He completed his field-work by a resurvey of the city of San Francisco, in order to make the outlets to the westward conformable to the present directions of the roads. The material of the several plane-table sheets were then collected and combined, part by part, in the preparation of a compre-

hensive map for the Engineer Department. This labor has been nearly accomplished, and will result in the production of a very large sheet, unsurpassed in thoroughness and accuracy of detail.

Tidal observations.—The self-registering gauge at San Diego is still kept in operation by Mr. A. Cassidy, and that at Fort Point (San Francisco Entrance) by Mr. H. E. Uhrlandt, both being under the supervision of Major G. H. Elliot, of the Corps of Engineers, United States Army.

Mr. Uhrlandt has continued, also, as heretofore, the tabulation of the readings of high and low waters from the tide-rolls furnished by all the self-registering gauges on the Pacific coast.

SECTION XI.

COAST OF OREGON AND OF WASHINGTON TERRITORY.—(SKETCH No. 24.)

Topography and hydrography of Yaquina Bay, Oregon.—This survey was commenced on the 9th of July by Sub-Assistant A. W. Chase. From Newport, at the entrance, the bay extends about five miles, with an average width of two miles. It then contracts, and, as a river-channel, carries tidal water twenty miles further to Elk City.

After measuring a base-line of a thousand meters, Mr. Chase made a triangulation by means of the plane-table, to include the entrance, and three and a half miles of the outer coast on the north side of the entrance, or as far as Cape Foulweather, which is a prominent headland, and useful as a guide in approaching the entrance of the bay. The plane-table survey was made to embrace the entire bay, and the approaches north and south for several miles. Soundings were continued as the shore-line survey was advanced, and, by the close of October, the hydrography of the bar, including the approaches, and the bay was completed. A tide-gauge was kept in operation while the soundings were in progress, and the currents were observed at two stations.

The result of the survey of the bar seems to have given general satisfaction to the inhabitants whose interests depend upon the development. Already a company has been formed for the construction of a railway to carry the produce of the Willamette Valley to the head of Yaquina Bay, from whence it can be transported in vessels to San Francisco. Sub-Assistant Chase was aided in this survey by Mr. Stehman Forney. The following are statistics of the field-work:

Shore-line surveyed, (miles)	16½
Area of topography, (square miles)	6
Miles run in sounding	200
Sextant angles	1,720
Number of soundings	8,552

On a ledge of rock outside of the entrance to the bay, Mr. Chase found at one place a depth of only six feet at mean low water. His recommendation, that the ledge should be marked by buoys, has been made known to the Light-House Board.

The bar has on it nine feet at mean low water, but the channel across it, as reported by Sub-Assistant Chase, is so straight, and so well defined by the breakers on each side, that with a pilot or chart to guide them, vessels drawing ten, twelve, or even thirteen feet can enter or depart with safety by choosing the time of tide. As shown by the chart of soundings, (Sketch No. 25,) the bar is quite narrow. All the dangers to navigation in the approaches, the character of the bar, course and capacity of the channel, and other particulars of great local interest, including sailing directions for entering Yaquina Bay, were communicated by Mr. Chase to the authorities of Newport in October, and have been made known to the inhabitants through the newspapers of Oregon. A tracing from the plane-table sheet of the entrance has been furnished also to the engineer of the light-house district, Lieutenant Colonel R. S. Williamson, United States Engineers.

Before returning to San Francisco Mr. Chase made perspective drawings or views of the entrances in the vicinity, as well as that of Yaquina Bay. His drawings include a view of Cape Foulweather, and views of the openings made in the coast by Eel River and Rogue River.

A compass reconnaissance was run along the coast to the southward as far as Cape Perpetua. Then seeking the highest point on the cape, Mr. Chase took compass bearings on the surrounding peaks and other coast features, including Corvallis, Alseya River and Mountain, Cape Foulweather, Scott's Peak, and several others.

Reconnaissance of Nehalem River Entrance, Oregon.—This entrance, which opens into the Pacific about thirty miles south of the mouth of the Columbia River, was examined in September by Sub-Assistant G. Farquhar, of the party of Assistant Cordell, with the schooner Marcy. Owing to the lateness of the season, it was impracticable to sound on the bar, but in that direction soundings were made about a mile outside of the entrance. A depth of seven feet was found in mid-channel. The spit which bounds it on the west is formed in part by a kind of quicksand. Fog and smoke prevailed in the whole region during the visit of the hydrographic party. Judging from the breakers, Mr. Farquhar concluded that the depth of water on the bar in September, at mean low tide, was not more than five feet.

Stone-coal has been found on a branch of the Nehalem, at a short distance from the mouth of the river.

Topography of the Columbia River, Oregon.—The plane-table survey of this season, by Assistant Cleveland Rockwell, has been confined to the southern bank of the river. Commencing at Astoria on the 1st of July, the topographical survey was carried, in the course of the season, eastward somewhat beyond the mouth of John Day's River, and westward to include part of the sea-coast of the Pacific beyond Point Adams. Assistant Rockwell was aided by Mr. L. A. Sengteller. The following is a synopsis of the statistics of field-work:

Shore-line surveyed, (miles)	39
Marsh, islands, &c., (miles)	59
Area of topography, (square miles)	19

This survey is comprised on two sheets, of which one includes the peninsula of Point Adams, the location of the military post of Fort Stevens, and the south side of the river as far as Young's Bay. The second sheet represents the vicinity of Astoria, Tongue Point, and other features within the plane-table limits. The surface details of the two sheets mark plainly the change of character that occurs at Young's Bay, the shore of the river above it being high and bold.

"The whole country is not only covered with a heavy growth of the largest evergreen timber, but densely clothed with thick and impenetrable bushes, chiefly of the berry-bearing class. This dense jungle is the principal impediment in prosecuting the topographical survey. The north (or Washington Territory) side of the river is very bold, almost mountainous. Cliffs and precipices occur at almost every point.

"Above the remarkable neck of land called Tongue Point, where the river widens into a large sheet of water known as Cathlamet Bay, there are again large areas of tide lands, or swamps, intersected by numerous channels. Some of these channels are navigable, and are used by the small steamers plying between Astoria and Portland.

"The smoke from fires in the forest became quite troublesome at the end of August, and soon after enveloped the whole country, obscuring the sun and seriously impeding navigation even at sea. For this reason no work could be done on a third plane-table sheet, which was projected to include part of the north side of the Columbia, above Cape Disappointment."

The party of Assistant Rockwell is now engaged on the shore of the Santa Barbara Channel.

Hydrography of Columbia River, Oregon, (Sketch No. 26.)—This important survey, commenced at the outset of the present working season, was prosecuted during the winter by Assistant Edward Cordell with a party in the schooner Marcy, and was completed near the end of last April, leaving at that date outstanding the development of the bar and approaches.

Relative to the survey of the river between Three Tree Point and Gray's Bay, Mr. Cordell reports: "A careful examination of the waters to the northward of the Snag Islands developed a new channel, wider and straighter and with 1½ feet more water than the channel heretofore used, to the southward of those islands. Since the discovery of the new channel obviates the necessity of passing over two other bars of 14½ feet in the old channel, vessels will hereafter, when the new one is buoyed, avail themselves of it and find only one spot, of 16 feet shoalest water, obstructing its passage."

The inside channels and passages between Tongue Point and Cathlamet Head, used by river-steamers only, were also sounded out, and the outlines were traced of the islands, marshes, flats, and bare shoals existing in Cathlamet Bay.

The hydrography of the Columbia being specially called for by the Chief of Engineers, Major General Humphreys, the survey in all its details was made conformable to the wishes of the Engineer Department. These were made known to the working parties by General Barton S. Alexander, of the Corps of Engineers. For the work at the bar and in the approaches, the steam-tug Katy was assigned by that officer to coöperate with the hydrographic party of Assistant Cordell. With that assistance the survey was vigorously pushed, and was finally completed on the 8th of September.

Great and remarkable changes since the year 1852 were developed in sounding at the entrance of the river. In reference to the entire work the hydrographic inspector remarks: "The results of this survey are important, first, in the discovery of a channel above Astoria, having nearly two feet more water than the old channel; and, secondly, the development of the changes on and about the bar. These last verify the traditional laws of change as well as the results of former surveys The permanent main channel is the *north* channel. The south channel, now the *apparent* main channel, is temporary, and at present in its most favorable condition. It has hitherto, from this position, gradually approached Point Adams, contracting its width and shoaling its bar, until it ran close along the beach, where it ultimately closed. In the mean time Sand Island and the middle sands moved eastward, and the north channel widened until it became the only navigable channel. The south channel would not again become navigable until in the course of years, say eight or ten, it had worked out to the westward below Sand Island, to its present position."

In reference to the north channel Assistant Cordell reports: "It is more crooked and contracted than formerly, and the depth of water on the bar has decreased from five to three and a quarter fathoms. During strong northwest winds it breaks completely across the bar."

For the special use of the Engineer Department, Mr. Cordell made a triangulation of the mouth of the Columbia, marking as stations Cape Disappointment, Chinook Point, Point Adams, and Sand Island. The stations were secured by blocks of sandstone. The results of the triangulation, giving the distances and geographical positions, were furnished to Captain Raymond, United States Engineers, in charge of Fort Stevens. Upon the data thus derived the topography of the Columbia Entrance was prosecuted by Assistant Rockwell.

In connection with the soundings near the bar, and simultaneous with those near Astoria, tidal observations were made during two lunations at Cape Disappointment, and at Fort Stevens, (Point Adams.) An intermediate tide-gauge was erected in a little cove at Sand Island, but Assistant Cordell was forced to abandon it because of its exposed position. High and low water, and the direction of the currents, were repeatedly observed in twelve fathoms water, outside of the bars of the north and south channels. Commodore Watson, light-house inspector, assigned the schooner Ellen to aid in the observations, and Mr. Cordell furnished in return all needful information respecting the buoys for the channels embraced in his survey. At the request of Commodore Watson the hydrographic party in the Marcy took up the sea-buoy off the entrance to the north channel, (to be placed off the south channel entrance,) and placed a first-class red buoy near the entrance, point of Clatsop Spit, for the guidance of vessels clearing that point.

The prosecution of soundings on the Columbia River during winter was attended with danger to the safety of the surveying vessel. Freezing weather in January, followed by strong northeast winds, filled the lower part of the river with large fields of floating ice, and though Mr. Cordell hastened to get the Marcy into a place of shelter, a considerable part of the copper sheathing was torn off and the planking was cut two inches deep by the ice-drift in less than half an hour. The vessel was saved by being beached at Young's Point. No disaster occurred to the members of the party, although the night of the 8th of January was passed in great personal peril, not only to them, but to the crews of other vessels in the river. The Marcy was next day safely moored at the steamer's wharf at Astoria, and with slight repairs was used during the entire season.

The statistics of the hydrographic survey of the Columbia River, including the bar and approaches, are as follows:

Miles run in sounding..
Angles...
Number of soundings..

Sub-Assistant Farquhar was attached to the hydrographic party, and during the latter part of the season Mr. Albert P. Redding served as aid.

Triangulation of the Strait of Fuca, Washington Territory.—When my last annual report closed Assistant J. S. Lawson was still engaged in the vicinity of Protection Island, in triangulation work, with a view of perfecting the connection between the astronomical stations at Victoria and Point Hudson. This was partially done, notwithstanding the smoky atmosphere and very unfavorable weather prevailing at that period. The opportunity was taken to reset and to make more permanent the marks for identifying the important astronomical station at Point Hudson. After turning in the results of field-work to Assistant Davidson, Mr. Lawson resumed the triangulation at New Dungeness, but, finding much hinderance in the prevailing southeast gales, soon transferred his party to Steilacoom, and closed the working season in the field by additional measurements in the triangulation of Puget Sound. The brig Fauntleroy was then taken to Olympia and laid up for the winter. Assistant Lawson and his aid, Mr. J. J. Gilbert, then engaged in the office-work and computations. All the sheets and records due from the party have been received. The following is a synopsis of the triangulation:

Stations occupied	12
Objects observed	54
Angles measured	44
Number of observations	2,322

After completing a survey that will be mentioned under the next heading, the party of Assistant Lawson returned to this vicinity, and traced about six miles of the shore-line to the westward of Point Wilson, and mapped the neighboring features.

Mr. Lawson is now engaged in the plane-table survey of Port Discovery. This work was preceded by connecting the local triangulation previously done there with the triangulation of the Strait of Fuca, determined by the party last year. Six stations were occupied in perfecting the connection, and over a thousand angular measurements were made with the theodolite.

Topography and hydrography of Port Madison, Washington Territory, (Sketch No. 27.)—The survey at Port Madison, which is on the west side and about midway in the course of Admiralty Inlet, was taken up by Assistant Lawson early in the present surveying season. The plane-table sheet contains the details adjacent to about twenty-five miles of shore-line, and also the northern entrance to Port Orchard, which is connected by a water-passage with the western side of Port Madison. The surface of Port Madison covers about fifteen square miles. A tide-gauge was early started and was kept in operation while the party was occupied in field-work and hydrography. The soundings were made mostly with the boats of the brig Fauntleroy, but the temporary use of a steam-launch was had in running lines out to the deep water of Admiralty Inlet in the approaches to Port Madison. The hydrographic statistics are as follows:

Miles run in sounding	288
Angles measured	1,178
Number of soundings	11,120

At the request of Lieutenant Colonel Williamson, Assistant Lawson accompanied that officer on a tour of inspection through Admiralty Inlet and Puget Sound, and communicated in writing the results of his personal experience and observation relative to the lights needful for navigation in those waters. The report was accompanied by a chart marked to show the positions of lights deemed advisable, and also by topographical sketches showing the sites recommended.

Tidal observations.—Mr. L. Wilson has remained in charge of the self-registering tide-gauge at Astoria, Oregon, under the supervision of Major G. H. Elliot, of the United States Engineers. Mr. Wilson still continues his comprehensive record of meteorological phenomena.

COAST OF ALASKA.—(SKETCHES NOS. 20, 21, AND 22.)

Alaska reconnaissance.—Assistant George Davidson, after returning from the coast of Alaska, passed the winter and spring in drawing and inking the surveys made during the reconnaissance expedition, and in collecting and combining for chart purposes the off-shore soundings. In the course of the season, Mr. Davidson collated information from upward of eighty published volumes,

and combined the results of his own observations in preparing the Alaska Coast Pilot, similar in character to the useful Directory of the Pacific Coast of the United States, of which two editions have been given in the appendix of previous annual reports on the coast survey. Assistant Davidson is now at San Francisco in general charge of the field operations on the western coast, and preparing to make a reconnaissance for continuing the main triangulation of the coast of California. Before sailing in November, he had prepared a third edition of his Directory, which is about to be issued as a Coast Pilot for California, Oregon, and Washington Territory. Under the direction of Mr. Davidson, the astronomical work of the Alaska expedition has been computed by Sub-Assistant A. T. Mosman, and also the results of the local triangulations made at Sitka, St. Paul, and Ilioulionk. Sixteen of the numerous views drawn while the party was on the coast of Alaska have been lithographed under the immediate supervision of the chief of the party. The attention of Assistant Davidson has also been given to the extension of the list of time-stars used in the survey for astronomical purposes; an aggregate of twelve thousand observations being thus noted for the positions of stars.

The Alaska Coast Pilot is nearly complete in manuscript, and will be published at an early day.

COAST SURVEY OFFICE.

The general direction of the operations in the Office of the Coast Survey, where the materials gathered by the field-parties are combined and published, has remained as heretofore with Assistant J. E. Hilgard. The work of the Office is kept close up to the field-work; the results of each season are fully elaborated within the subsequent year, and all accumulation of back work is thus avoided, except so far as the completion of the survey over more extended areas affords the data for comprehensive adjustments of geodetic results and for charts of a general character. Such final elaborations are likewise effected whenever practicable. The operations of the past year are briefly stated below.

In the computing division, under the able charge of Assistant C. A. Schott, the force employed and distribution of duties has been the same as for several years past; Assistant T. W. Werner computing the current triangulations; Dr. G. Rumpf making the verifications of the same by comparison with the field computations, keeping the registers of geographical positions, and making the computations for the final adjustment of the triangulation, assisted by Mr. E. Courtenay, who also performed the clerical work of the division, while Mr. J. Main made computations of astronomical work.

The computations of adjustment by the method of least squares have received the personal attention of Mr. Schott, who in all cases established the conditional equations. Among his labors may be specially mentioned the computation of the geodetic measure of an arc of the meridian passing through Nantucket, which forms the subject of Appendix No. 9; the adjustment of the secondary triangulation of Long Island Sound, Appendix No. 8; special computations of considerable magnitude relating to the changes in a tidal wave entering a harbor; and observations of the magnetic declination, dip, and intensity on three days of each month throughout the year.

The tidal division has been continued under the charge of Mr. R. Avery, by whom, with the assistance of Mr. A. Gottheil and Mr. J. Downes, the tide-tables for the year 1869, for the principal ports of the United States, have been computed, and their publication supervised. The reductions of tidal observations in progress at stations on the coast have been kept up, and tables of tidal constants for all the charts prepared during the year have been supplied. A somewhat extended discussion of three series of tidal observations at Sitka may be specially mentioned, as well as an examination of the remarkable earthquake waves observed on the Pacific coast. In the general work of the division some aid was rendered by Miss M. Thomas.

In the hydrographic division the work of the sounding parties is mapped, the reduced drawings of hydrography or charts prepared for publication are verified, sailing directions and all other notes relative to navigation are prepared, under the direction of C. P. Patterson, inspector of hydrography, by Mr. E. Willenbücher, aided by Mr. J. Sprandel.

The work in the drawing division has been carried on under the immediate direction of Assistant Hilgard, aided by W. T. Bright, whose assistance in planning the work and in preparing

map projects has been of great value. Drawings for engraved charts have been made by A. Lindenkohl, chief draughtsman, and by Messrs. H. Lindenkohl, L. Karcher, and F. Fairfax. Traced copies of maps have been made by W. Fairfax and B. Hooe. Copies of manuscript maps and charts, or portions of such, are frequently furnished, upon request, to other branches of the public service, as well as to private persons, the latter of course paying for the cost thereof. This is an important form in which the information collected by the Coast Survey becomes available to the public, and a list of the maps so furnished during the year is given in Appendix No. 2. A list of the maps and charts, either wholly drawn during the year or the work on which has been continued as far as the material on hand permitted, together with the names of the persons engaged upon them, is given in Appendix No. 3. Views of head-lands and approaches to harbors have been taken during the year by Mr. W. McMurtrie, and were afterward drawn by him for engraving on the charts.

Engraving division.—Under the efficient superintendence of Assistant E. Hergesheimer, the work in this important branch of the Office has made good progress, and a marked gain in economy has been effected, without any decline in the quality or style of the work, which, on the contrary, has improved in force and perspicuity. Forty-eight charts have been in progress of engraving during the year, of which nineteen have been completed and published. There has been no change in the engraving force since the previous year. The charts worked upon, and names of engravers engaged upon them, are given in Appendix No. 4.

Messrs. J. Enthoffer, H. C. Evans, A. Rolle, and A. Sengteller have engraved the first-class topography. Messrs. J. C. Kondrup, A. M. Maedel, R. F. Bartle, and W. A. Thompson have been engaged upon topography; and Messrs. H. S. Barnard, W. A. Thompson, and F. W. Benner upon sanding. The first-class lettering has been engraved by Messrs. J. Knight and E. A. Maedel. Messrs. A. Petersen, J. G. Thompson, and E. H. Sipe have also been engaged upon lettering. Soundings upon the preliminary charts have been punched by Mr. A. Buckle. Mr. E. Molkow has pantographed the outlines of the $\frac{1}{40000}$ scale charts.

The clerical duties of the division have been performed, until July 1, by Mr. W. N. Meeks, and since that date by Mr. G. A. Morrison.

The *electrotyping* and *photographing* have been continued by Mr. George Mathiot. Thirty-one copper plates—nearly all of the largest class—have been made by the electrotype process, seventeen of which were mold-plates, or "altos," taken from engraved plates, and fourteen were printing plates, or "bassos." Three of the altos, viz, "Savannah and Wassaw," coast chart Nos. 5 and 28, were constructed by fitting together portions of other plates, and incorporating them by the electrotype process. The photographic reduction of topographical sheets to the scales of publication, as patterns for the engraver, has been continued as heretofore.

The division of *charts* and *instruments*, which includes besides the safe-keeping of the archives and instruments, the map-printing, sale and distribution of charts and reports, the instrument and carpenter shops, has been under the supervision of Mr. J. T. Hoover. The duty of registering and filing the original maps and charts of the survey, and the records of observations made in the field, as well as keeping an account of the same as they are used in the Office, has been performed by Mr. A. Zumbrock. Twenty-five topographic and forty-seven hydrographic sheets have been turned into the Office during the year, and one hundred and ninety volumes of trigonometrical, astronomical, and magnetical observations, two hundred and seventy-one sounding-books, and eighty-eight tide-books.

The copper-plate printing has been done by Mr. T. V. Durham; the map-room has been in the care of Mr. T. McDonnell, and Mr. H. Nissen has prepared the backed drawing-paper for field and office use, besides performing the miscellaneous duties pertaining to the folding-room.

An aggregate of thirteen thousand nine hundred charts have been issued during the year, and four thousand three hundred copies of annual reports of various years have been distributed.

The work of repairing instruments, and of reconstructing those now out, has been performed, under the supervision of Mr. W. Würdemann, by J. Foller, C. W. Black, and W. Jacobi. The woodwork of instruments, their packing for transportation, and all work of carpentry required in the Office has been done by Mr. A. Yeatman, assisted, during part of the time, by George Plimley.

The clerical duties of correspondence and accounts of the Office have been, as during past years,

performed by Mr. V. E. King, assisted by Mr. William H. Davis. In the hydrographic division Mr. T. Emory, and, in the engraving division, Mr. George A. Morrison have been employed as copyists.

PROFESSIONAL PAPERS.—Besides the memoirs already mentioned in their proper connection, there appear in the appendix to this report the following papers of a professional character, illustrating the methods and practice of the Coast Survey, viz: No. 6. Mode of forming a brief tide-table for a chart, by R. S. Avery, in charge of the tidal division of the Office; No. 7. Memoranda relating to the practice of the secondary triangulation of the Coast Survey, prepared by Assistant R. D. Cutts; No. 10. Addenda to Appendixes Nos. 9 and 11 of Report for 1866, relating to observations for time and azimuth, prepared by Assistant Charles A. Schott; No. 11. Note on Gulf Stream explorations, by Assistant H. Mitchell.

GEOGRAPHICAL POSITIONS.—The list of geographical positions of stations determined in the progress of the Coast Survey is continued from previous reports in Appendix No. 13.

GEOGRAPHICAL NAMES.—Much embarrassment has been experienced in the Office from the unsettled orthography of names of Indian origin, and from the frequent changes in local names derived from those of proprietors. The assistant in charge of the Office has availed himself of the advice of persons, in different parts of the country, learned in the aboriginal tongues, or conversant with the history of the settlements and the original names of families and localities.

He takes this occasion to express his great indebtedness to the late Professor J. H. Alexander, LL.D., of Baltimore, who had the kindness to revise the nomenclature on the charts of Chesapeake Bay and its estuaries. It is to be regretted that his notes, scattered over maps and in letters, are not in a form to be readily combined into a memoir, as they are full of matters of historical, archæological, or linguistic interest.

A similar discussion, in a more systematic form, for the coast of Maine, has been undertaken, at the instance of Assistant Hilgard, by the Rev. Edward Ballard, secretary of the Maine Historical Society, whose first contribution is printed at the end of this report, as Appendix No. 14.

ISTHMUS OF DARIEN.

In the spring of 1867, Assistant Davidson, after having collated the best information then extant in regard to the Isthmus of Darien, and in particular the observations made on the ground by M. Hellert, embodied the results, which will be found in Appendix No. 15. These, with his suggestions based on a personal visit to the Isthmus of Panama in the preceding winter, in regard to means and expedients for prosecuting explorations, are inserted for any reference that may be desirable in future, in view of the interest now manifested by the public in reference to the practicability of a ship-canal across the isthmus.

CONCLUSION.

During the illness of my lamented predecessor, the administration of the survey fell upon the shoulders of the assistant in charge, J. E. Hilgard, esq. The distinguished ability with which this difficult service was discharged was manifest to all. His familiarity with all the operations and officers of the survey was thereby strengthened. He has extended to me the benefits of this experience liberally and loyally. While I willingly acknowledge myself under deep and lasting obligations to him for the aid thus rendered me, I can also testify that in all respects he has been equally true to my predecessor, the greatness of whose reputation has not been diminished in his keeping.

The important services rendered by Samuel Hein, esq., general disbursing agent of the Coast Survey, deserve earnest commendation; his experience, rigid and systematic economy, and unerring rectitude contribute essentially to the easy progress of the survey. My principal clerk, W. W. Cooper, esq., must also receive my hearty commendation for unwearied exertions in the performance of his duties.

Respectfully submitted.

BENJAMIN PEIRCE,
Superintendent United States Coast Survey.

Hon. HUGH MCCULLOCH,
Secretary of the Treasury.

APPENDIX.

6

APPENDIX No. 1.

Distribution of the parties of the Coast Survey upon the coasts of the United States during the surveying season of 1867–'68.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION I.				
Atlantic coast of Maine, New Hampshire, Massachusetts, and Rhode Island.	No. 1	Triangulation.....	G. A. Fairfield, assistant; F. W. Perkins, aid.	Triangulation for the plane-table survey of the Fox Islands and others, in the entrance of Penobscot Bay. (See also Section IV.)
	2	Topography	F. W. Dorr, assistant; H. G. Ogden and Joseph Hergesheimer, aids.	Topography of Vinal Haven and of islands southward of the Thoroughfare, in Penobscot Bay. (See also Sections IV and VIII.)
	3	Hydrography	Charles Junken, sub-assistant; L. B. Wright and G. W. Bissell, aids.	Soundings developing the Fox Island Thoroughfare and its east and west approaches. Hydrography of Penobscot Entrance continued eastward of Seal Island Rock. (See also Section V.)
	4	Topography	W. H. Dennis, assistant; F. H. Agnew, aid, (part of season.)	Plane-table survey of Tennants' Harbor, Seal Harbor, and Mosquito Harbor, and of the adjacent shore of George's River, Me. (See also Section V.)
	5	Topography	Charles Hosmer, sub-assistant; O. H. Tittmann, aid.	Topography of the Medomak River completed, and survey of part of the west side of George's River, Me. (See also Section V.)
	6	Hydrography	R. E. Halter, sub-assistant; W. W. Harding, sub-assistant, (part of season;) W. I. Vinal, aid.	Soundings between Pemaquid Point and Allen's Island, completing the hydrography of Muscongus Bay, Me. (See also Sections III and IX.)
	7	Triangulation.....	S. C. McCorkle, assistant..........	Triangulation of Kennebec River, Me., extended from Merrymeeting Bay northward to Augusta. (See also Section VII.)
	8	Hydrography	J. S. Bradford, sub-assistant; Geo. C. Schaeffer, jr., aid.	Development of ledges near Kennebec Entrance and in that river. Sounding of Damiscove Harbor and of the vicinity of Cape Small Point. Additional soundings in Wiscasset Harbor, and development of Half-Way Rock, in Casco Entrance, Me. (See also Section IV.)
	9	Topography	C. H. Boyd, sub-assistant	Plane-table survey of Half-Way Rock, in the entrance to Casco Bay, Me. (See also Section VIII.)
	10	Topography	A. W. Longfellow, assistant.......	Detailed survey of the shores of Winnegance Bay and of the lower part of New Meadows River, Me.
	11	Triangulation, topography, and hydrography.	J. A. Sullivan, assistant; Horace Anderson, sub-assistant; A. Lindenkohl and J. N. McClintock, aids.	Munjoy Hill minutely surveyed for the city authorities of Portland, Me. Hydrographic development of the vicinity. (See also Section VIII.)
	12	Triangulation.....	Charles Ferguson, sub-assistant...	Triangulation of Saco Bay, Me., between Wells Village and Richmond Island. (See also Section V.)
	13	Triangulation, topography, and hydrography.	C. H. Boyd and H. W. Bache, sub-assistants; J. G. Spaulding, aid.	Triangulation of the vicinity of Dennis, Brewster, Orleans, Harwick, and Chatham, (Cape Cod Peninsula.) Topography of the vicinity of Chatham. Hydrography of Pleasant Bay. (See also Sections IV and VIII.)
	14	Topography	Hull Adams, assistant; H. L. Marindin, aid.	Plane-table survey of Cape Cod Bay between Orleans and Brewster, and of the Coast of the peninsula between Nausett and the entrance to Pleasant Bay. (See also Section VI.)
	15	Topography	P. C. F. West, assistant............	Detailed survey of Sursuit and Nobscusset Harbors, (Cape Cod Bay,) and of the bay shore between Brewster and North Dennis. Resurvey of Monomoy Point, Mass.
	16	Hydrography	F. F. Nes, sub-assistant	Soundings on the Shovelfull Shoal and in the vicinity of Pollock Rip, off Monomoy, Mass. (See also Sections II and IX.)
	17	Triangulation	F. P. Webber, assistant	Determination of the position of the light-ship on the "Hen and Chickens," (Buzzards' Bay.) (See also Section VIII.)

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION I—Continued.	No. 18	Triangulation	S. C. McCorkle, assistant	Points determined for the plane-table survey of the shore of Wickford Bay, R. I., and adjacent shores of Narraganset Bay. (See also Section VII.)
	19	Topography	A. M. Harrison, assistant; H. M. De Wees, sub-assistant.	Detailed topography of the shores of Narraganset Bay continued, in the vicinity of Wickford Harbor, Warwick Neck, Greenwich Bay, and near Warren, R. I. (See also Section VII.)
	20	Hydrography	F. P. Webber, assistant; F. D. Granger and A. P. Barnard, aids.	Hydrography of Narraganset Bay completed by soundings, in the vicinity of Canonicut Island, Hope Island, and Quonset Point. (See also Section VIII.)
		Tidal observations.	A. C. Mitchell, G. D. Wooster, H. Howland.	Observations with self-registering tide-gauge at Owl's Head (Penobscot Entrance) closed. Series continued with the same instrument at North Harbor, Penobscot Bay. Continuous observations at Charlestown navy yard, Mass.
SECTION II.				
Coast of Connecticut, New York, and New Jersey, including, also, Pennsylvania and part of the coast of Delaware.	1	Triangulation	John Farley, assistant	Primary station-points examined on the coast of Connecticut, New York, and New Jersey, and others between Philadelphia and the head of Chesapeake Bay.
	2	Tides & currents, topography and hydrography.	F. H. Gerdes, assistant; F. F. Nes, sub-assistant.	Levelings along the East River at Hell-Gate, and special observations on the tides and currents. Hydrographic resurvey for pilot commissioners of the harbor channel between New York City and Staten Island. Plane-table and hydrographic survey of the entrance to Rondout Creek; and examination of hydrographic changes in the vicinity of the lights on the river between Hudson City and Albany, N. Y. (See also Sections I and IX.)
	3	Triangulation	W. S. Edwards, assistant	Connection of geodetic work of New York Harbor with the triangulation of the coast of New Jersey.
	4	Topography	C. M. Bache, assistant; Eugene Ellicott, aid.	Plane-table survey of the coast of New Jersey between Squan River and Barnegat Bay. (See also Section V.)
		Tidal observations.	R. T. Bassett, A. C. Mitchell	Series of observations continued with self-registering tide-gauge on Governor's Island, (New York Harbor;) and with the box-gauge at Hamilton Ferry, Brooklyn. Bench-marks established at stations on the coast of New Jersey.
SECTION III.				
Coast of part of Delaware; coast of Maryland; and part of the coast of Virginia.	1	Geodetic operations.	C. O. Boutelle, assistant; F. H. Agnew, aid.	Hill Station and Webb, near Washington City, occupied as points in the primary triangulation south of Kent Island base. Magnetic elements determined at both stations. (See also Sections I and V.)
	2	Topography and hydrography.	J. W. Donn, sub-assistant; R. B. Palfrey, aid, (part of season.)	Plane-table survey and sounding of estuaries on the west side of Chesapeake Bay.
	3	Hydrography	Clarence Fendall, sub-assistant, (part of season;) A. F. Pearl, aid; W. W. Harding, sub-assistant, (part of season.)	Hydrography of estuaries on the east side of Chesapeake Bay, and soundings in the dependencies of Mobjack Bay, Va. (See also Sections I and IX.)
	4	Hydrography	J. W. Donn, sub-assistant	Development of the vicinity of Bowler's Rock and Corner Rock in Rappahannock River.
	5	Hydrography	Acting Master Robert Platt, U. S. N., assistant; Gershom Bradford and J. B. Adamson, aids.	Soundings in Elizabeth River, Va., defining the dimensions of the "Merrimack" wreck, as an obstruction to the navigation. (See also Sections IV and VI.)
		Tidal observations.	E. F. Krebs	Observations continued with the self-registering tide-gauge at Old Point Comfort, Va.
SECTION IV.				
Coast of part of Virginia and coast of North Carolina.	1	Reconnaissance	Richard D. Cutts, assistant; F. W. Perkins, aid.	Site selected for base-line and scheme of triangulation laid out for connecting stations near Cape Henry, Va., with the Bodie's Island base on the coast of North Carolina.

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION IV—Continued.	No. 2	Hydrography	Acting Master Robert Platt, U. S. N., assistant; Gershom Bradford, and J. B. Adamson, aids.	Hydrography extended southward of False Cape, along the coast of North Carolina. (See also Sections III and VI.)
	2	Triangulation	G. A. Fairfield, assistant; F. W. Perkins, aid.	Triangulation of Pamplico Sound, N. C., extended in the vicinity of the entrance to the Neuse River. (See also Section I.)
	3	Topography	F. W. Dorr, assistant; H. W. Bache, sub-assistant.	Detailed survey of the shores of Neuse River, N. C., completed by topography below Smith's Point and Cedar Point. (See also Section I.)
	4	Hydrography	J. S. Bradford, sub-assistant; F. D Granger and George C. Schaeffer, jr., aids.	Hydrography of the Neuse River completed by soundings at its junction with Pamplico Sound, N. C. (See also Section I.)
SECTION V.				
Coast of South Carolina and Georgia.	1	Primary triangulation.	C. O. Boutelle, assistant; Charles Ferguson, sub-assistant; J. N. McClintock, aid, (part of season.)	Extension of the primary triangulation of the coast of South Carolina to stations on the Savannah River. (See also Sections I and III.)
	2	Topography and hydrography.	Charles Hosmer, sub-assistant; J. N. McClintock, aid, (part of season.)	Detailed survey of Parry Island, S. C.; part of St. Helena Island, and others adjacent to Chowan and Beaufort Rivers; also of the neck between Beaufort River and Battery Creek. Hydrography of the vicinity of Jericho Creek. (See also Section I.)
	3	Topography	C. M. Bache, assistant; Eugene Ellicott, aid.	Topography of the lower part of Ossabaw Island at the entrance to St. Catharine's Sound, Ga., and detailed survey of the shores of St. Andrew's Sound. (See also Section II.)
	4	Topography	W. H. Dennis, assistant; J. G. Spaulding, aid.	Plane-table survey of the shores of Doboy Sound, Ga. (See also Section I.)
	5	Hydrography	Charles Junken, sub-assistant; L. B. Wright and G. W. Bissell, aids.	Hydrographic survey including Doboy Sound, Ga., and its entrance, and the bar and approaches. (See also Section I.)
SECTION VI.				
Atlantic, and part of the Gulf coast of Florida, with the reefs and keys.	1	Topography and hydrography.	C. T. Iardella, sub-assistant; H. L. Marindin, aid.	Topography of the Florida Peninsula east of Cape Sable, and of the adjacent keys. Soundings in the same vicinity. (See also Section I.)
	2	Hydrography	Acting Master Robert Platt, U. S. N., assistant; Gershom Bradford and J. B. Adamson, aids.	Hydrography of the approaches to the Florida Reef. Determination of shoals in the vicinity of the Marquesas, and to the southward of Loggerhead Key. Deep-sea soundings for special purposes. (See also Sections III and IV.)
	3	…………	L. F. Pourtales, assistant; Henry Mitchell, assistant.	Deep-sea soundings and observation of ocean currents in the vicinity of Salt Key Bank, and across the Gulf Stream, and St. Nicholas and Santaren Channels. Investigations relative to the growth of coral.
SECTION VII.				
Gulf coast of Western Florida, and of part of Alabama.	1	Triangulation and topography.	S. C. McCorkle, assistant; H. M. De Wees, sub-assistant.	Triangulation completed and shore line survey made of St. Joseph's Bay, north of Cape San Blas, Fla. (See also Section I.)
	2	Triangulation and topography.	J. G. Oltmanns, assistant; F. H. Agnew, aid.	Azimuth determinations and linear measurement of the Gulf coast between Perdido Bay and Mobile Point, Ala. (See also Sections I and III.)
SECTION VIII.				
Gulf coast of part of Alabama, of Mississippi, and of part of Louisiana.	1	Triangulation and topography.	C. H. Boyd, sub-assistant; H. G. Ogden, aid.	Triangulation of Bird Island Sound, Grand Bay, and part of Isle au Breton Sound. Shore line survey of the east bank of the Mississippi River, and of lagoons in the same vicinity. (See also Section I.)
	2	Hydrography	F. P. Webber, assistant; Horace Anderson, sub-assistant; A. P. Barnard, aid.	Soundings completed in Garden Island Bay, in East Bay, and in West Bay, between the passes of the Mississippi. (See also Section I.)
	3	Longitude and latitude.	G. W. Dean, assistant; Edward Goodfellow, assistant; F. Blake, jr., aid; S. C. Chandler, jr., aid.	Astronomical observations and telegraphic exchanges at New Orleans for the longitude of Galveston. Determination of the latitude and longitude of Ship Shoal light-house off Last Island, La. (See also Section IX.)

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION IX.				
Coast of part of Louisiana and coast of Texas.	No. 1	Longitude, latitude, and magnetic observations.	G. W. Dean and Edward Goodfellow, assistants; F. Blake, jr., and S. C. Chandler, jr., aids.	Longitude of Galveston, Tex., determined by telegraphic exchanges. Latitude observations at Lavaca, Tex. Magnetic elements determined at both stations. (See also Section VIII.)
	2	Hydrography	R. E. Halter, sub-assistant; C. P. Dillaway and R. B. Palfrey, aids.	Soundings and observations on the currents at Galveston Entrance for the Engineer Department. Hydrography extended in Matagorda Bay and Lavaca, Tex. (See Section I.)
	3	Hydrography	F. F. Nes and W. W. Harding, sub-assistants; A. L. Ross, aid.	Hydrographic survey of Aransas Pass, Tex., and soundings continued in Corpus Christi Bay. (See also Sections I and II.)
SECTION X.				
Pacific coast of California.	1	Triangulation and topography.	W. E. Greenwell, assistant	Secondary triangulation of the coast of California from San Buenaventura toward Point Duma, and topography of the coast of Santa Barbary Channel from Santa Barbara toward San Buenaventura.
	2	Topography	Aug. F. Rodgers and Cleveland Rockwell, assistants; G. Farquhar, sub-assistant; A. W. Chase and L. A. Sengteller, aids.	Completion of the detailed plane-table survey of the peninsula near San Francisco for the Engineer Department, and resurvey of the western environs of the city of San Francisco, Cal. (See also Section XI.)
	3	....	George Davidson, assistant	Compilation, for the use of navigators, of a general coast pilot for California, Oregon, and Washington Territory. (See also Section XII.)
		Tidal observations.	Major G. H. Elliot, U. S. engineers; H. E. Uhrlandt; A. Cassidy.	Series of tidal observations continued, with self-registering gauges, at the permanent stations, San Diego and Fort Point, near San Francisco, Cal.
SECTION XI.				
Coast of Oregon and coast of Washington Territory.	1	Topography and hydrography.	A. W. Chase, sub-assistant; Stehman Forney, aid.	Plane-table reconnaissance and hydrography of Yaquina Bay, Oreg.; and sketches of the adjacent coast of the Pacific, northward to Cape Foulweather, and southward to Cape Perpetua. (See also Section X.)
	2	Hydrography	G. Farquhar, sub-assistant........	Soundings to develop the channel of the Nehalem River, Oregon. (See also Section X.)
	3	Topography	Cleveland Rockwell, assistant; L. A. Sengteller, aid.	Topographical survey of the south shore of the Columbia River, Oreg., from Point Adams upward to John Day's River, including Young's Bay and the vicinity of Astoria. (See also Section X.)
	4	Hydrography	Edward Cordell, assistant; G. Farquhar, sub-assistant; A. P. Redding, aid.	Hydrographic survey of the bar and of the lower part of the Columbia River, Oreg., for the use of the Engineer Department.
	5	Triangulation, topography, and hydrography.	James S. Lawson, assistant; J. J. Gilbert, aid.	Triangulation of the Strait of Fuca, in the vicinity of Protection Island, and near New Dungeness. Plane-table survey and hydrography of Port Madison, Admiralty Inlet, W. T.
		Tidal observations.	Major G. H. Elliot, U. S. Engineers; L. Wilson.	Observations continued with the self-registering tide-gauge at Astoria, Oreg. (See also Section X.)
SECTION XII.				
Coast of Alaska.........	....	....	George Davidson, assistant; A. T. Mosman, sub-assistant.	Computation from the records of triangulation and latitude observations made in the reconnaissance of the coast and harbors of Alaska; construction of charts and views; and compilation of a general coast pilot. (See also Section X.)

APPENDIX No. 2.

Information furnished from the Coast Survey Office, by tracings from original sheets, &c., in reply to special calls, during the year 1867–'68.

Date.		Names.	Data furnished.
1867.			
December	11	Brevet Maj. Gen. A. A. Humphreys, Chief Engineer United States Army.	Hydrography and topography of Point Sal and vicinity, Cal.
	11	John de la Camp, civil engineer	Topography of Chincoteaque Bay and vicinity, Md. and Va.
1868.			
January	20	E. L. Meyer, city surveyor, Elizabeth, N. J.	Topography of west shore of Newark Bay, N. J.
	27	S. T. Abert, civil engineer	Topography of part of Potomac River near Fort Washington.
Febuary	4	Maj. and Brevet Col. Nicholas Bowen, United States Engineers.	Copy of survey off the Battery, New York Harbor.
	12	Mayor of Savannah, Ga.	Hydrography of city front.
	18	Light-House Board	Topography of northeast shore of Staten Island, with adjacent hydrography.
	25	C. B. Colt, esq	Topography of Highlands of Navesink and Sandy Hook, N. J.
March	17	Hon. F. A. Pike, Me	Topography of Calais, Me.
April	27	Brevet Maj. Gen. A. A. Humphreys, Chief Engineer, United States Army.	Topography head of Barnegat Bay and mouth of Metedeconk River, N. J.
	28	M. L. Delafield, esq	Topography of Hunting Island, S. C.
May	11	Harbor commission, Mass	Topography of entrance to Ipswich Harbor, Mass.
	23	John de la Camp, civil engineer	Topography of Assateague Island, Md. and Va.
	27	Professor W. P. Trowbridge	Topography of northwest part of Long Island, from Hunter's Point to Flushing Bay, with Blackwell's Island.
July	3	Brig. Gen. W. E. Merrill, Corps of Engineers	Sketch of the Mississippi Delta, and part of the river.
	10	Hudson Highland Suspension Bridge Company	Shore-line of Hudson River, from Buttermilk Falls to Cauldwell's Landing.
August	7	Col. T. L. Casey, Corps of Engineers	Topography of Mount Desert Island, Me.
	10	A. B. Conger, esq	Shore-line of the Hudson River, and hydrography, from Warren to Stony Point.
	13	Brevet Brig. Gen. J. H. Simpson, Corps of Engineers.	Hydrography of part of Potomac River from Broad Creek to Little Hunting Creek.
	13	R. H. Ives, esq	Heights on Prudence, Narraganset Bay, R. I.
September	7	Hon. Edmund Munson, England	Topography and hydrography of Duxbury Beach and vicinity.
October	1	Brevet Brig. Gen. J. J. Dana, United States Army	Topography of Brazos Santiago and Boca Chica Entrances, Texas.
	6	Brevet Brig. Gen. J. H. Simpson, Corps of Engineers.	Hydrography of part of Boston Inner Harbor.
	20	Captain G. V. Fox	Map of Atlantic coast, from Great Boar's Head to Wood Island.
November	4	W. F. Bonzano, light-house engineer	Topography of head of passes, Mississippi River.
	18	Light-House Board	Topography of Sand Islands, entrance to Mobile Bay.

APPENDIX No. 3.

DRAWING DIVISION.

Charts completed or in progress during the year ending November, 1868.

1. Hydrography. 2. Topography. 3. Drawing for photographic reduction. 4. Details on photographic outlines. 5. Verification. 6. Lettering. 7. Plotting hydrography.

Title of charts.	Scale.	Draughtsman.	Remarks.
General coast chart No. I, Quoddy Head to Cape Cod	1–400, 000	1, 2. A. Lindenkohl	Additions.
General coast chart No. II, Cape Ann to Gay Head	1–400, 000	2. A. Lindenkohl	Additions.
Winter Harbor, Me	1–20, 000	1, 2. F. Fairfax. 2. H. Lindenkohl. 7. A. Balbach.	
St. George's River and Muscle Ridge Channel, Me	1–40, 000	1. A. Lindenkohl.	
Tennant's Harbor, Me	1–10, 000	1. A. Balbach. 1. W. B. McMurtrie	Completed.
Coast chart No. 5, White Head light to Seguin light	1–80, 000	3. J. Hergesheimer. 4. H. Lindenkohl.	
Coast chart No. 6, Seguin light to Wood Island light	1–80, 000	3. J. Hergesheimer. 3. L. Karcher.	
Bangor to Hampton, Me	1–2, 000	2. W. Bawmann	Completed.
Sheepscot and Kennebec Rivers, Me	1–40, 000	1. H. Lindenkohl	Additions.
Bath to Booth Bay, Me	1–20, 000	1. H. Lindenkohl.	
Casco Bay, Me	1–40, 000	1. A. Lindenkohl	Hydrog'y; complet'd.
Portland Harbor, Me	1–20, 000	1. L. Karcher	Additions.
Portsmouth Harbor, N. H	1–20, 000	2. L. Karcher. 2. W. B. McMurtrie	Completed.
Coast chart No. 7, Seguin light to Cape Porpoise light	1–80, 000	1. A. Lindenkohl.	
Boston Harbor, Mass	1–40, 000	2. A. Lindenkohl	Additions.
Duxbury Bay, Mass		7. A. Balbach	Completed.
Coast chart No. 8, Boon Island light to Gloucester Harbor	1–80, 0000	1. A. Lindenkohl. 3. L. Karcher. 3. J. Hergesheimer. 4. F. Fairfax. 4. H. Lindenkohl.	
Atlantic coast No. I, Cape Sable to Sandy Hook	1–1, 200, 000	1. A. Lindenkohl	Additions.
Medomak River, Me		7. A. Balbach	Completed.
Coast chart No. 9, Boston Bay, Mass	1–80, 000	2. H. Lindenkohl.	
Coast chart No. 10, Cape Cod Bay, Mass	1–80, 000	3. L. Karcher. 4. H. Lindenkohl.	
Sea-coast chart No. 3, Small Point, Me., to Cape Cod, Mass.	1–200, 000	1. A. Lindenkohl	Additions.
Provincetown Harbor, Mass		7. A. Balbach	Completed.
Sippican Harbor, Mass	1–20, 000	2. H. Lindenkohl	Completed.
Coast chart No. 13, Narragansett Bay, R. I	1–80, 000	1. A. Lindenhohl. 3. L. Karcher. 3. J. Hergesheimer. 4. H. Lindenkohl.	
Warren River, R. I., (preliminary edition)	1–10, 000	1. L. Karcher. 2. F. Fairfax	Completed.
Coast chart No. 20, New York Bay and Harbor	1–80, 000	1. H. Lindenkohl. 2. H. Lindenkohl	Additions.
Hudson River No. 1, New York to Haverstraw	1–60, 000	2. H. Lindenkohl	Additions.
New York lower bay	1–40, 000	2. H. Lindenkohl.	
Coast chart No. 23, Absecum to Cape May	1–80, 000	2. H. Lindenkohl	
Delaware breakwater, sketch of	1–40, 000	1. A. Balbach. 2. A. Balbach	Completed.
Coast chart No. 27, Cape May to Isle of Wight Shoal	1–80, 000	1. H. Lindenkohl	Completed.
General coast chart No. IV, Cape May to Cape Henry	1–400, 000	2. H. Lindenkohl	Additions.
Coast chart No. 33, Chesapeake Bay, from Pocomoke Sound to Potomac River.	1–80, 000	2. H. Lindenkohl	Additions.
Coast chart No. 34, Chesapeake Bay, from Potomac River to Choptank River.	1–80, 000	2. H. Lindenkohl	Additions.
Hampton Roads and Elizabeth River	1–40, 000	1. L. Karcher	Additions.
General coast chart No. V, Cape Henry to Cape Lookout	1–400, 000	1. A. Lindenkohl. 2. A. Lindenkohl	Additions.
Neuse River, N. C		7. A. Balbach	Completed.
Atlantic coast No. III, Cape Hatteras to Mosquito Inlet	1–1, 200, 000	1. A. Lindenkohl	Additions.
General coast chart No. VII, Cape Roman to St. Mary's River.	1–400, 000	2. H. Lindenkohl	Additions.
Coast chart No. 54, Long Island to St. Helena Sound, including Charleston Harbor.	1–80, 000	2. H. Lindenkohl. 3. J. Hergesheimer.	
Coast chart No. 55, Hunting Island to Ossabaw Sound, including Savannah River.	1–80, 000	1. A. Lindenkohl. 3. J. Hergesheimer. 4. H. Lindenkohl. 4. F. Fairfax.	
Charleston Harbor, S. C	1–30, 000	2. A. Lindenkohl	Additions.
Savannah River and Wassaw Sound, Ga	1–40, 000	6. F. Fairfax	Completed.
Coast chart No. 56, Savannah River to Doboy Sound	1–80, 000	2. H. Lindenkohl. 5. L. Karcher.	
Savannah River	1–40, 000	1. L. Karcher	Additions.
St. Helena Sound, S. C	1–40, 000	2. F. Fairfax	Additions.
St. Catherine's Sound, Ga	1–40, 000	1. L. Karcher. 2. F. Fairfax.	
Straits of Florida, (diagram)		1. H. Lindenkohl	Completed.
General coast chart No. X, straits of Florida	1–400, 000	2. H. Lindenkohl	Additions.
General coast chart No. XIII, Cape San Blas to Mississippi Delta.	1–400, 000	2. H. Lindenkohl. 2. A. Lindenkohl	Additions.

APPENDIX No. 3—Continued.

Title of charts.	Scale.	Draughtsmen.	Remarks.
Coast chart No. 94, Mississippi Delta	1–80, 000	2. H. Lindenkohl.	
General coast chart No. XVI, Galveston to the Rio Grande	1–400, 000	2. H. Lindenkohl	Additions.
Galveston Entrance, Tex	1–40, 000	1. L. Karcher. 2. F. Fairfax.	
Galveston Harbor, Tex		7. A. Balbach	Completed.
West Galveston Bay, Tex		7. A. Balbach	Completed.
Brazos Santiago, Tex	1–20, 000	1. H. Lindenkohl. 2. H. Lindenkohl	Completed.
Reconnaissance of western coast, from San Diego to San Francisco, Cal.	1–1, 200, 000	1. A. Lindenkohl. 2. A. Lindenkohl. 2. H. Lindenkohl.	Additions.
Point Sal, Cal	1–20, 000	1. H. Lindenkohl. 2. H. Lindenkohl	Completed.
San Francisco Entrance	1–50, 000	2. H. Lindenkohl	Additions.
City of San Francisco	1–10, 000	5. W. B. McMurtrie	Additions.
Suisun Bay, Cal	1–40, 000	1. A. Lindenkohl.	
Reconnaissance of western coast from San Francisco to Umpquah River.	1–1, 200, 000	1. A. Lindenkohl. 2. A. Lindenkohl. 2. H. Lindenkohl.	Additions.
Reconnaissance of western coast from Umpquah River to northwest boundary.	1–1, 200, 000	1. A. Lindenkohl. 2. A. Lindenkohl. 2. H. Lindenkohl.	Additions.
Shilshole Bay, W. T	1–20, 000	1. L. Karcher. 2. F. Fairfax	Completed.
Tillamook Bay, Oreg	1–20, 000	1. L. Karcher	Completed.
Washington Sound, W. T., (new edition)	1–200, 000	2. A. Lindenkohl	Completed.
Alaska Territory, (new edition)		2. A. Lindenkohl.	
Diagrams		A. Lindenkohl, L. Karcher, H. Lindenkohl.	

APPENDIX No. 4.

ENGRAVING DIVISION.

Plates completed, continued, or commenced during the year.

1. Outlines. 2. Topography. 3. Sanding. 4. Lettering.

Titles of plates.	Scale.	Engravers.
COMPLETED.		
Portsmouth Harbor	1-20, 000	2. J. C. Kondrup.
Sippican Harbor	1-20, 000	1, 2. W. A. Thompson. 4. J. G. Thompson.
Core Sound	1-40, 000	1, 3. E. H. Sipe. 4. A. Buckle.
Charleston Harbor	1-30, 000	1, 2. R. F. Bartle. 3. H. S. Barnard. 4. A. Petersen.
Section of Gulf Stream, Key West to Havana		1, 4. E. H. Sipe.
Section of Gulf Stream off Chorrera		1, 4. E. H. Sipe.
Charlotte Harbor	1-40, 000	2, 4. J. G. Thompson.
San Francisco Bay, (upper)	1-50, 000	3. W. A. Thompson.
Koos Bay	1-40, 000	2, 3. W. A. Thompson.
CONTINUED.		
General coast chart No. II	1-400, 000	1, 2. A. M. Maedel.
General coast chart No. IV	1-400, 000	3. H. S. Barnard. 4. E. A. Maedel.
General coast chart No. V	1-400, 000	3. H. S. Barnard. 4. E. A. Maedel.
General coast chart No. XIII	1-400, 000	1, 2. A. M. Maedel.
Coast chart No. 5, Whitehead Light to Seguin Island	1-80, 000	1, 2. H. C. Evans. 4. J. Knight.
Coast chart No. 6, Seguin Island to Fletcher's Neck	1-80, 000	1, 2. H. C. Evans. 4. J. Knight.
Coast chart No. 7, Seguin Island to Kennebunkport	1-80, 000	4. J. Knight and E. A. Maedel.
Coast chart No. 8, Cape Neddick to Cape Ann	1-80, 000	1, 2. A. Sengteller. 4. J. Knight.
Coast chart No. 9, Boston Bay	1-80, 000	2. J. Enthoffer and J. C. Kondrup. 4. E. A. Maedel.
Coast chart No. 10, Cape Cod Bay	1-80, 000	1, 2. H. C. Evans.
Coast chart No. 13, Buzzard's Bay to Block Island	1-80, 000	1. A. Rollé. 2. H. C. Evans.
Coast chart No. 27, Cape May to Isle of Wight	1-80, 000	3. H. S. Barnard. 4. J. Knight.
Coast chart No. 28, Isle of Wight to Chincoteague	1-80, 000	4. E. A. Maedel.
Coast chart No. 30, Chesapeake Entrance	1-80, 000	4. J. Knight.
Coast chart No. 54, Long Island to Hunting Island	1-80, 000	3. H. S. Barnard. 4. E. A. Maedel.
Coast chart No. 55, Hunting Island to Ossabaw	1-80, 000	1, 2. A. Sengteller. 4. E. A. Maedel.
Coast chart No. 67, Elbow to Lower Matecumbe	1-80, 000	3. H. S. Barnard.
Coast chart No. 79, Cedar Keys, &c	1-80, 000	1, 2. A. Sengteller.
Eastport Harbor	1-40, 000	3. F. W. Benner. 4. E. A. Maedel.
St. George's River and Muscle Ridge Channel	1-40, 000	3. F. W. Benner. 4. A. Petersen.
Damariscotta River, &c	1-40, 000	1. R. F. Bartle and E. Molkow.
Kennebec and Sheepscot Rivers	1-40, 000	3. W. A. Thompson. 4. E. A. Maedel and A. Petersen.
Casco Bay	1-40, 000	1. R. F. Bartle. 4. A. Petersen.
Boston Harbor	1-40, 000	1, 2. A. Rollé and J. C. Kondrup. 4. H. S. Barnard.
New York Bay and Harbor, (upper)	1-40, 000	1. R. F. Bartle and E. Molkow.
New York Bay and Harbor, (lower)	1-40, 000	4. E. A. Maedel.
Hampton Roads and Elizabeth River	1-40, 000	1, 4. E. H. Sipe. 3. F. W. Benner.
St. Helena Sound	1-40, 000	2. J. C. Kondrup.
Caloosa Entrance	1-40, 000	1. R. F. Bartle. 2. J. C. Kondrup. 3. F. W. Benner. 4. J. G. Thompson.
Half Moon Bay	1-20, 000	2. W. A. Thompson.
Washington Sound	1-200, 000	2. A. M. Maedel. 3. W. A. Thompson. 4. A. Petersen.
Progress sketches for annual report		W. A. Thompson, J. G. Thompson, and E. H. Sipe.
COMMENCED.		
Northwest coast No. 1	1-1, 200, 000	1. R. F. Bartle.
General coast chart No. I	1-400, 000	1, 2. J. Enthoffer. 4. E. A. Maedel.
General coast chart No. VII	1-400, 000	1, 2. A. M. Maedel. 4. E. A. Maedel.
General coast chart No. XVI	1-400, 000	1. A. M. Maedel.
Coast chart No. 94, Mississippi River Entrance	1-80, 000	1. A. Rollé.
Winter Harbor	1-20, 000	1, 2. W. A. Thompson. 3. F. W. Benner. 4. J. G. Thompson and A. Buckle.
Inside Passage Bath to Booth Bay	1-20, 000	1. R. F. Bartle. 3. W. A. Thompson. 4. E. A. Maedel and J. G. Thompson.
Warren River	1-10, 000	1. E. H. Sipe. 3. E. H. Sipe and F. W. Benner. 4. J. G. Thompson and E. H. Sipe.
Narraganset Bay, (upper)	1-40, 000	1. E. Molkow.
Savannah River and Wassaw Sound	1-40, 000	1, 4. A. Petersen. 3. H. S. Barnard and A. Petersen.
Suisun Bay	1-40, 000	1. W. A. Thompson. 3. W. A. Thompson and F. W. Benner. 4. A. Petersen and J. G. Thompson.
Point Sal	1-20, 000	1, 2. W. A. Thompson. 4. J. G. Thompson.
Shilshole Bay	1-20, 000	1, 2. W. A. Thompson. 3. F. W. Benner. 4. J. G. Thompson.
Tillamook Bay	1-20, 000	1, 2. F. W. Benner. 4. E. H. Sipe.

APPENDIX No. 5.

DISCUSSION OF TIDES IN BOSTON HARBOR.

CAMBRIDGE, MASSACHUSETTS, *May* 2, 1870.

DEAR SIR: I have the honor to submit the following report of a discussion of the Boston dry-dock tide observations. On account of the completeness of the set of observations and the importance of the tide-station, as representing a peculiar, and, in relation to the tidal theory, a very interesting, type of tides, extending along the whole coast of New England, it has been thought advisable to give all the labor to the discussion necessary to obtain the most accurate results, and also to give a somewhat full report of them. Some applications of the results have also been made to theory, and practical formulæ and tables constructed for the prediction of the tides.

THE OBSERVATIONS AND LOCALITY.

1. The series of observations used in this discussion embrace a period of nineteen years, commencing with the 1st of July, 1847, and extending to the 1st of July, 1866. The series is very nearly complete, the observations of the times and heights of both high and low water having been made with great regularity both day and night, and for every day of the week; so that it rarely happened that even a single observation was lost. Only on two occasions were there any interruptions of any consequence in the whole series. During the latter part of May, and the first part of June, 1854, one week's observations were lost, owing to the observer's being on duty to check the mob at the time of the Burns trial. The observations of ten days, also, of the latter part of January, 1865, were lost on account of the illness of the observer.

The first part of the series of observations was made with a tide-gauge consisting of marks designated by copper figures set in the stone wall at the entrance to the dry-dock. The observer commenced usually about a half hour before each high and low water and noted the readings every five minutes until the stand, then the duration of the stand, and then again he noted the readings every five minutes until he felt sure the tide had changed. In 1860 a box-gauge was substituted, which was used until the series was closed, on the 30th of September, 1866, the full series having been commenced in June and continued about nineteen years and four months.

The observations seem to have been accurately made, so far as can be judged from the grouping of them in the discussion; but this is rather an uncertain criterion, since numerous astronomical inequalities, and also meteorological irregularities, necessarily cause a considerable range in the observations of each group. The most accurate test of the faithfulness of the observer is found in the slight irregularities caused by the diurnal tide. These irregularities in both the heights and times of the tide at the Boston dry-dock are quite small, and only sensible to ordinary inspection of the observations at certain periods; yet these irregularities can generally be readily distinguished in the recorded observations, amid all the other numerous irregularities, at such times as theory indicates that they should be most easily seen. It is not probable that the observer knew either the periods of these irregularities, or their character, and hence their occurring in the record must have resulted from a careful observation of the tides.

This discussion has not been made from the original records of the observer, but from what are called the first reductions of the tide observations, in which are given the apparent times of the moon's meridian transit, and the apparent times and absolute heights of high and low water, and the lunitidal intervals, as obtained from the observer's record. These reductions, so far as I had any means of testing them, seem to have been carefully and accurately made.

2. On account of the shallowness of the greater part of the harbor, and even of the bay for many miles beyond, and the interruptions of numerous islands, and the narrowness of the channel leading to the Boston dry-dock, the tide-station must be regarded as a somewhat inland one, and some of the characteristics of river-stations should be found in the observed tide. It is seen, from consulting the Coast Survey chart of the bay and harbor, that the average depth of the channel in

the harbor for ten miles ranges mostly from five to ten fathoms, and beyond that in the open bay for many miles there is only a very gradual increase of the depth of the sea. The vast expanse, also, of comparatively shallow ocean over the Banks of Newfoundland, over which the greater part of the tide originating in the deeper ocean has to travel, no doubt affects the character of the tides. In any casual considerations of the character of the tides and of the results of this discussion, these general circumstances of the tide-station should be considered, but in any critical study of them, of course, the charts of the Coast Survey should be consulted, in which all the minute circumstances are accurately laid down.

EXPRESSIONS OF THE DISTURBING FORCES.

3. In the discussion of tide observations it is necessary to have some form of expression of the disturbing forces, and to know something of the tidal expressions corresponding with them. Theory must furnish the arguments to be used in any discussion, but different forms of expression give different arguments. In the complete solution of the tidal problem it is necessary to have a development of the disturbing forces into a series of terms containing angles, which increase in proportion to the time, and the corresponding tidal expression has then a similar form; but very accurate approximate tidal expressions may be obtained in which the expressions contain circular arguments, but in which the angles do not increase exactly in proportion to the time. Such expressions may be obtained which contain a much smaller number of sensible terms than in the case in which the development is required to contain only terms with angles increasing exactly in proportion to the time; and the arguments in the expression, still being circular arguments, are much preferable to parallax and declination arguments, since all the observations, within certain equal limits of the argument, have nearly the same number of observations; and the results obtained from a discussion of the observations in this way are of much more importance in any theoretical study and investigation of the tides, since the constant coefficients and the angles of epoch show the relations between each term in the tidal expression and the corresponding term in the disturbing force.

4. Since the forms of expression of the disturbing forces used in this discussion, and likewise the notation, are for the most part entirely different from those contained in any treatise on the tides to which reference could be made, it is necessary to give them here.

If we put

Ω = the potential of the moon's disturbing force;
μ = its mass;
r = its distance from the center of the earth;
ψ = its right ascension;
v = its declination;
ϖ = the terrestrial longitude of any place:
θ = its polar distance;
$n\,t$ = the earth's rotatory motion;

we have, from the development of Ω,

$$\Omega = \Sigma_s \mathrm{N}_s \cos s\,(n\,t + \varpi - \psi) \tag{1}$$

in which

$$\left\{\begin{aligned} \mathrm{N}_0 &= \frac{\mu}{4\,r^3}(1 - 3\cos^2\theta)(1 - 3\sin^2 v) \\ \mathrm{N}_1 &= \frac{3\,\mu}{4\,r^3}\sin 2\theta \sin 2v \\ \mathrm{N}_2 &= \frac{3\,\mu}{4\,r^3}\sin^2\theta \cos^2 v \\ \mathrm{N}_3 &= \frac{3\,\mu}{8\,r^3}\sin^3\theta \cos^3 v \end{aligned}\right. \tag{2}$$

There is also a small term depending upon the fourth power of the moon's distance, which produces a sensible effect, of the form

$$\mathrm{N} = \frac{15\,\mu}{4\,r^4}\cos\theta \sin^2\theta \cos^2 v \sin v \tag{3}$$

5. If we likewise put

$$\Omega' = \text{the potential of the sun's disturbing force,}$$

and let μ', r', ψ', and v' denote the same with regard to the sun, which the same letters without an accent do with regard to the moon, we shall have

$$(4) \qquad \Omega' = \Sigma_s \mathrm{N}'_s \cos s\,(n\,t + \varpi - \psi')$$

in which the expressions of N'_s are the same as those of N_s with μ, r, ψ, and v accented.

In the preceding expressions the origin of t must be such as to make the angle $n\,t + \varpi - \psi$ or $n\,t + \varpi - \psi'$ equal to $i\pi$, that is, some multiple of π, when the moon or sun is on the meridian of the place with regard to which the force is considered. The values of s may be 0, 1, 2, &c., but there are no terms producing sensible effects in which s is greater than 3.

6. In the comparison of tides with the forces producing them, it is necessary to either analyze the result and tide of the moon and sun in each port into its component parts, or to have the resultant of the component forces of the moon and sun with which to compare them. The latter is preferable in tidal discussions and investigations, since the developed expressions of the resultant of the forces of the moon and sun being obtained, and all the constants accurately determined, these expressions, depending mostly upon celestial circumstances, serve, with a very few convenient modifications, for every port; whereas if the former method is adopted, a troublesome analysis, and a determination of the constants belonging to each component of the tide, must be made for each port.

By combining the preceding components, we get

$$(5) \qquad \Omega + \Omega' = \Sigma_s \sqrt{\mathrm{N}_s^2 + \mathrm{N}'^2_s + 2\,\mathrm{N}_s \mathrm{N}'_s \cos s\,(\psi - \psi')}\, \cos s\,(n\,t + \varpi - \psi + \beta_s)$$

in which

$$(6) \qquad \tan s\,\beta_s = \frac{\mathrm{N}'_s \sin s\,(\psi - \psi')}{\mathrm{N}_s + \mathrm{N}'_s \cos s\,(\psi - \psi')}$$

7. If we put

$$\Omega_s = \text{the part of the preceding expression belonging to } s,$$

its development may be expressed in the following form:

$$(7) \qquad \Omega_s = \mathrm{C}_s\, \Sigma_i\, \mathrm{P}_i \cos \eta_i \cos s\,(n\,t + \varpi - \psi + \beta_s)$$

in which the angles η_i and $n\,t + \varpi - \psi + \beta_s$ do not increase exactly in proportion to the time on account of the variable motions of the moon and sun in their orbits, and the obliquity of the ecliptic. The latter angle also varies with the changing value of β_s which expresses the angle in right ascension between the moon and the position of a disturbing body which would represent the resultant of that part of the forces of the moon and sun belonging to the characteristic s. In the preceding expression C_s is the constant or average value of the coefficient of $\cos s\,(n\,t + \varpi - \psi + \beta_s)$, and is independent of any of the inequalities. Its value depends upon terrestrial circumstances, and consequently is different in different ports. The constants P_i and the angles η_i depend upon celestial circumstances only, and consequently are the same for every port. The constants P_i are different for different values of s, and should be denoted by $\mathrm{P}_{(s,\,i)}$ when it is necessary to distinguish them. P_0 is the constant of integration and is equal to unity.

8. We shall now give the angles and the numerical values of the constants, and also the mean values of the first derivatives of the angles in terms of the radius, belonging to the principal terms in the preceding expression of Ω_s for each value of s. In the expressions of the angles the following notation is used:

v = the moon's mean anomaly;
v' = that of the sun;
φ = the moon's longitude;
φ' = that of the sun;
ω = the longitude of the moon's ascending node.

From the notation (§§ 4 and 5) we also have

$\psi - \psi'$ = the difference in right ascension between the moon and sun, usually expressed by the apparent time of moon's transit.

We shall also put, for the mean values of r and r',

$$(8)\qquad \begin{cases} Z=\dfrac{3\mu}{4r^3} \\ Z'=\dfrac{3\mu'}{4r'^3} \\ e=\dfrac{Z'}{Z} \end{cases}$$

If we put, in terms of the earth's mass,

$$(9)\qquad \mu=.013+\delta\mu$$

in which $\delta\mu$ is the correction of the assumed mass of the moon, we shall have

$$(10)\qquad e=.4380-33.8\,\delta\mu$$

9. With the preceding constants and notation, when $s=0$, (7) gives

$$(11)\qquad \Omega_0=C_0\,\Sigma_i\,P_i\cos\eta_i$$

in which, omitting the correction of the moon's mass,

$$(12)\qquad \begin{cases} C_0= & .254\,(1-3\cos^2\theta)(1+e)\,Z & \\ P_2= & .114, & \eta_2=v \\ P_3= & .217, & \eta_3=2\varphi \\ P_4= & .016, & \eta_4=v' \\ P_5= & .095, & \eta_5=2\varphi' \\ P_6= & -.025, & \eta_6=\omega \end{cases}$$

The term belonging to $i=1$, in this case, is wanting.

10. When $s=1$, the development of the resultant of the moon and sun in the general form of (7) is not sufficiently convergent for practical purposes, and therefore expressions must be obtained for the moon and sun separately in this case. The only terms, in the case of the moon, which we shall have occasion to use in this discussion, may be most conveniently expressed in the following form, β vanishing in this case:

$$(13)\qquad \Omega_1=C_1\sin\varphi\cos(nt+\varpi-\psi)$$

in which

$$(14)\qquad C_1=.731\sin 2\theta\,Z$$

In the case of the sun we shall likewise have

$$(15)\qquad \Omega'_1=C'_1\sin\varphi'\cos(nt+\varpi-\psi')$$

in which

$$(16)\qquad C'_1=.731\,e\sin 2\theta\,Z$$

11. When $s=2$, (7) gives

$$(17)\qquad \Omega_2=C_2\,\Sigma_i\,P_i\cos\eta_i\cos 2\,(nt+\varpi-\psi+\beta_2)$$

in which

$$(18)\qquad \begin{cases} C_2= & .9564\sqrt{1+e^2}\sin^2\theta\,Z & & \\ P_1= & .4305-24.0\,\delta\mu, & \eta_1=2(\psi-\psi'), & D_t\eta_1=.426 \\ P_2= & .1521+\ \ 3.6\,\delta\mu, & \eta_2=v, & D_t\eta_2=.229 \\ P_3= & .0985+\ \ 1.0\,\delta\mu, & \eta_3=2\varphi, & D_t\eta_3=.460 \\ P_4= & .0093-\ \ 1.0\,\delta\mu, & \eta_4=v', & \\ P_5= & .0053-\ \ 1.0\,\delta\mu, & \eta_5=2\varphi', & \\ P_6= & -.0375, & \eta_6=\omega, & \\ P_7= & .0375, & \eta_7=2\varphi-\omega, & D_t\eta_7=.462 \\ P_8= & .0085, & \eta_8=\eta_1+\eta_2, & D_t\eta_8=.655 \\ P_9= & .0085, & \eta_9=\eta_1-\eta_2, & D_t\eta_9=.197 \\ P_{10}= & -.0470+\ \ 4.7\,\delta\mu, & \eta_{10}=2\eta_1, & D_t\eta_{10}=.852 \end{cases}$$

The unit of time in the preceding derivatives is one solar day.

12. When $s=3$, (7) gives only one term producing any sensible effect upon the tides, which may be expressed by

$$(19)\qquad \Omega_3=C_3\cos 3\,(nt+\varpi-\psi).$$

in which

$$(20)\qquad C_3=.0146\sin^3\theta\,Z$$

13. Putting

(21) $$i = 2\,D_t\,(n\,t - \psi + \beta_2)$$

it is necessary, in the various tidal expressions, to know the principal constants in the following expressions:

(22) $$i = \Sigma_i\, U_i \cos \eta_i, \text{ and } \frac{2\,\beta_2}{i} = \Sigma_i\, Q_i \sin \eta_i$$

The principal of these are

(23) $$\begin{cases} U_0 = 12.142, & \\ U_1 = \;\; .1742 - 13.2\,\delta\mu, & Q_1 = 52^m.5 - .4034\,\delta\mu \\ U_2 = -.0500, & \\ U_3 = \;\; .0477 - \;\; 0.5\,\delta\mu, & Q_3 = \;\; 2^m.2 - 148\,\delta\mu \end{cases}$$

The other values of U_i and Q_i are small, and, their effects being generally insensible, they are omitted here.

TIDAL EXPRESSIONS.

14. If we put

$Y =$ the height of the tide at any time above mean level;

$L =$ the lunitidal interval in solar time;

$\rho = n\,t + \varpi - \psi + \beta$;

$\tau_i =$ the time the maximum of any inequalities in the tides follows the maximum of the corresponding inequality of the disturbing force,

theory gives the following tidal expressions corresponding with the general expression (7) of the potential of the disturbing force:

(24) $$Y_s = K_s\, \Sigma_i\, R_i \cos(\eta_i - a_i) \cos(s\rho - l) = A_s \cos(s\rho - l)$$

in which

(25) $$\begin{cases} (1+F)\,R_i = P_i - E\,U_i \\ a_i = (\tau - B_0)\,D_t\,\eta_i \end{cases}$$

and

(26) $$L_s = \Sigma_i\, B_i \sin(\eta_i - \epsilon_i)$$

in which

(27) $$\begin{cases} B_i = \sqrt{M_i^2 + N_i^2} \\ \tan(\epsilon_i - a_i) = -\dfrac{N_i}{M_i} \\ M_i = -Q_i + \dfrac{1.035}{s}\,E\,P_i\,D_t\,\eta_i - \dfrac{0.164}{s}\,R_i\,D_t\,\eta_i \\ N_i = F'\,R_i \end{cases}$$

The value of B_0 is the *mean establishment of the port* belonging to the assumed transit.

15. Of the constants in these expressions, $E = Di\,K$ expresses the ratio between any change in i, the velocity with which the phase of the tide changes, and the corresponding change in the coefficient of the tide, and consequently the terms depending upon E show the effect of any change in the period of oscillation from the mean period. The constant F depends upon that part of friction in the theory which is supposed to affect the tides in a greater ratio than the first power of the velocity, and consequently affects the large tides more in proportion than the small ones, and, neglecting terms of a third order in the developments, affects the inequalities of the tides in a constant ratio. The terms depending upon F' express the corresponding effect upon the lunitidal intervals. All the constants in the preceding expressions have different values for different values of s, and they should be written $R_{(s,\,i)}$, $a_{(s,\,i)}$, &c., when it is necessary to distinguish them.

16. From the second of (25) we get

(28) $$\tau_i = B_0 + \frac{a_i}{D_t\,\eta_i}$$

The value of τ given by this expression has been called the *age of the tide from the heights.*

If we likewise put

(28[1]) $$\tau'_i = B_0 + \frac{\epsilon_i}{D_t\,\eta_i}$$

the value of τ'_1 in this expression has been called the *age of the tide from the times.*

The values of τ and τ' cannot be the same unless $a_i = \epsilon_i$, which can only be the case when F′ in (27) is equal 0. Hence, the difference depends on friction.

17. In the equilibrium theory all terms depending upon $U_{(i)}$ $D_t\,\eta$ and upon friction vanish, and (24) gives

(29) $$Y_s = K_s\, \Sigma_i\, P_i \cos \eta_i$$

in which, in the case of an ocean covering the whole earth with a fluid of insensible density, putting g for gravity,

$$K_s = \frac{C_s}{g}$$

In the case of nature the true values of K_s differ a little from these, but these may be regarded as very near approximate values. With the values of C_s, (12), (14), (18), (20), and with the value of

(30) $$\frac{Z}{g} = (.9224 + 71.1\,\delta\,\mu) \text{ ft.},$$

we get for the port of Boston, where $\theta = 47°\ 40'$, by neglecting the correction of the moon's mass,

(31) $$K_0 = -0.117 \text{ ft.}, K_1 = 0.711 \text{ ft.}, K_2 = 0.528 \text{ ft.}, K_3 = 0.006 \text{ ft.}$$

This value of K_0 is the mean or constant amount by which the mean level of the ocean is elevated by the moon and sun above the level which the water would assume in the case of no disturbing force. This value of K_0 may be also used in the hydrodynamic theory, since, when s$=0$, the oscillations depend upon the angles η_i in the expressions of Y_0, that is, upon the parallax and declination of the moon and sun, and hence are oscillations of long period compared with the diurnal and semi-diurnal oscillations. They are called by Laplace *oscillations of the first kind.*

18. When s$=1$, (24) gives as the tidal expressions corresponding to (13) and (15)

(32) $$\begin{cases} Y_1 = K_1 \sin(\varphi - a) \cos(\rho - l_1) \\ Y'_1 = K'_1 \sin(\varphi' - a') \cos(\rho' - l'_1) \end{cases}$$

in which

$$\rho' = n\,t + \varpi - \psi'$$

In this case we do not know the relation between C_1 and K_1, and consequently K_1 can only be determined from observation. In this case the period of the oscillations is one day, and the oscillations are called by Laplace *oscillations of the second kind.*

19. When $s=2$, (24) gives as the tidal expression corresponding with (17)

(33) $$Y_2 = K_2\, \Sigma_i\, R_i \cos(\eta_i - a_i) \cos(2\rho - l_2) = A_2 \cos(2\rho - l_2)$$

In this case the mean period of the oscillations is half of a mean lunar day, giving rise to the semi-diurnal tides. These Laplace calls *oscillations of the third kind.* The expression of L_2 in this case is derived from (26) and (27), putting $s=2$, and using the values of P_i, $D_t\,\eta_i$, U_i, and Q_i in (18) and (23).

20. If we change the assumed transit from which L_2 is reckoned n transits forward, then the constant B_0 is diminished n times $12^h\ 25^m.24$, and the whole of the corresponding change k in the expression of L_2 is

(34) $$k = -n\,(12^h\ 25^m.24 + 0^m.4 \cos \eta_1 + 3^m.0 \cos \eta_2 - 2^m.3 \cos \eta_3 \ldots)$$

This expression is only approximate when a change of several transits is made.

21. When s$=3$, the tidal expression corresponding with (19) is

(35) $$Y_3 = K_3 \cos(3\rho - l_3)$$

in which K_3 must be determined from observation. In this case the period of the oscillations is one-third of a day, and, in accordance with Laplace's method of designating them, they may be called *oscillations of the fourth kind.*

There may be local circumstances, such as the shallowness of the harbor or river, producing quarter-day tides, but these do not depend upon any sensible term in the disturbing force.

The tidal expression of the small term in the moon's disturbing force depending upon the fourth power of the distance (3), since $\sin v = \sin \epsilon \sin \varphi$, neglecting the inequality of the node, is of the form

(36) $$Y'' = K'' \sin(\varphi - a'')$$

22. The preceding are the tidal expressions belonging to the different kinds of oscillation taken separately; but for a comparison of observations with theory, and also for the purpose of prediction formulæ, it is necessary to have expressions of the height of the tide and of the lunitidal intervals belonging to the resultant of all the oscillations. If we put

H_0 = the height of the mean level of the sea above any assumed zero plane, in the case of no disturbing force,

then the expression of the height of high water at any time is $H_0+\Sigma_s Y_s$. If we put

H_n = the absolute height of the tide at the nth high or low water, $n=1$ belonging to the high water depending upon the upper transit;

λ_n = the corresponding lunitidal interval;

and also put

$$(37) \qquad \begin{cases} \lambda_n = L_2 + q_n \\ \varDelta = L_2 - L_1 \\ \varDelta' = L_2 - L_3 \end{cases}$$

we get, by combining the oscillations,

$$(38) \qquad \begin{cases} H_n = H_0 + A_0 + A_1 \cos \varDelta \cos q_n - A_1 \sin \varDelta \sin q_n + A_2 \cos 2\, q_n \\ \qquad + A_3 \cos 3\, \varDelta' \cos 3\, q_n - A_3 \sin 3\, \varDelta' \sin 3\, q_n \end{cases}$$

in which q_n must satisfy the conditions

$$(39) \qquad \begin{cases} 0 = A_1 \cos \varDelta \sin q_n + A_1 \sin \varDelta \cos q_n + 4\, A_2 \sin q_n \cos q_n \\ \qquad + 3\, A_3 \cos 3\, \varDelta' \sin 3\, q_n + 3\, A_3 \sin 3\, \varDelta \cos 3\, q_n \end{cases}$$

In general, there are four values of q_n which satisfy these conditions, two belonging to high waters and two to low waters. When A_1, however, is very large, there are only two values which satisfy them, and then there is only one high and one low water in a day.

The value of A_3 is always small, and when A_1 is also small, as it is at all ports in the North Atlantic, the value of q at high waters is so small that we can put $\cos q=1$, and at low waters so nearly equal to $\frac{1}{2}\pi$ that we can put $\sin q=1$. The preceding conditions then give

$$(40) \qquad \begin{cases} H_1 = H_0 + A_0 + A_1 \cos \varDelta - A_1 \sin \varDelta \sin q_1 + A_2 + A_3 \cos 3\, \varDelta' - A_3 \sin 3\, \varDelta' \sin 3\, q_1 \\ H_2 = H_0 + A_0 + A_1 \cos \varDelta \cos q_2 - A_1 \sin \varDelta - A_2 + A_3 \cos 3\, \varDelta' \cos 3\, q_2 + A_3 \sin 3\, \varDelta' \\ H_3 = H_0 + A_0 - A_1 \cos \varDelta - A_1 \sin \varDelta \sin q_3 + A_2 - A_3 \cos 3\, \varDelta' - A_3 \sin 3\, \varDelta' \sin 3\, q_3 \\ H_4 = H_0 + A_0 + A_1 \cos \varDelta \cos q_4 + A_1 \sin \varDelta - A_2 + A_3 \cos 3\, \varDelta' \cos 3\, q_4 - A_3 \sin 3\, \varDelta' \end{cases}$$

They also give

$$(41) \qquad \begin{cases} \sin q = -\dfrac{A_1 \sin \varDelta + 3\, A_3 \sin 3\, \varDelta'}{4\, A_2 + A_1 \cos \varDelta + 9\, A_3 \cos 3\, \varDelta'} \text{ at high waters, and} \\[2ex] \cos q = -\dfrac{A_1 \cos \varDelta + 3\, A_3 \cos 3\, \varDelta'}{4\, A_2 + A_1 \sin \varDelta + 9\, A_3 \sin 3\, \varDelta'} \text{ at low waters.} \end{cases}$$

When all the necessary constants are determined, the preceding equations (40) and (41) give H_n and q_n, and then when L_2 is determined, (37) gives λ_n, L_1, and L_3.

All the preceding expressions are taken from the manuscript of a forthcoming paper on the theory of the tides, in which they are more fully explained, but it would be impossible to give a complete and detailed explanation of them here. Few of them, however, depend upon any peculiar theory, and most of them can be verified by any one.

THE OBJECT AND PLAN OF THE DISCUSSION.

23. The object of the following discussion is, first, to obtain directly from observation the constants of all the principal terms entering into the preceding expressions of H_n and λ_n, which, it will be seen by referring to (24) and (26), comprise all the constants $R_{(s,i)}$, $\alpha_{(s,i)}$, $B_{(s,i)}$, and $\epsilon_{(s,i)}$, belonging to each one of the angles in the expressions; and, secondly, to obtain from these the general constants E, G, F, and F′ in the expressions (25) and (27), expressing the relations between all the preceding constants, so that they may all be made to depend upon these few constants. It is not proposed to determine merely so many of the former as are necessary to determine the latter, thus

making all the rest depend upon theory, but to determine all that are of much importance practically, so that they may be used in testing the accuracy of the general theoretical expressions, and for constructing approximate formulæ of prediction independently of any theoretical relations between the constants, or used by any investigator for verifying and improving any tidal theory. All the constants and relations being determined which are of theoretical importance, the most convenient practical formulæ will be constructed from the results for the prediction of the times and heights of high and low water, together with tables for facilitating the computations.

The plan adopted for determining the constants from the observations is to apply Lubbock's method of averages to circular arguments throughout, instead of to arguments of parallax and declination, and then to use the constants thus obtained to determine the constants belonging to any other forms of expression into which it may be thought advisable to put the results. As the quantities H_n and λ_n are the only ones which are directly observed, corresponding to any given time or values of the arguments, these must be determined from observations for all parts of the arguments separately by so grouping the observations that the effects belonging to all the other arguments are eliminated, and then, by means of the conditions (33), (37), (40), and (41), the constants belonging to each argument, as well as the general constants independent of any arguments, can be determined.

To obtain the values of H_n and λ_n belonging to the different parts of any argument η_n alone, all the observations within certain limits of the argument as from η'_i to η''_i have been grouped together, and the averages of all these have been taken as the normal values of H_n and λ_n belonging to the averages of all the corresponding values of the argument, which, when the number of the observations is considerable, does not differ much from $\frac{1}{2}(\eta'_i+\eta''_i)$, the mean of the two limits. If these limits should be somewhat wide, a slight correction to the averages of the observations may be necessary, which is easily applied. When the observations extend over a long period, and have been regularly made, the effects of all the inequalities belonging to other arguments are completely eliminated, since the periods of all the other arguments being different, the observations falling within certain limits of any one argument, are equally distributed through all parts of the other arguments, and all the plus and minus effects cancel one another; and this is especially the case in a series of nineteen years, which is very nearly a multiple of the periods of all the principal arguments in the tidal expressions. In a long series, also, the inequalities due to the winds and barometric changes, and whatever other abnormal disturbances there may be, are very nearly eliminated.

24. If the normal values of λ_n and H_n have been obtained from all the observations without regard to the arguments of the inequalities, then all the inequalities in λ_n and H_n depending upon these arguments disappear, as also A_1 and the inequalities of A_0, A_2, and A_3 in (40) and (41). Putting

$$\lambda'_1=\tfrac{1}{2}(\lambda_1+\lambda_3) \qquad H'_1=\tfrac{1}{2}(H_1+H_3)$$
$$\lambda'_2=\tfrac{1}{2}(\lambda_2+\lambda_4) \qquad H'_2=\tfrac{1}{2}(H_2+H_4)$$

we in this case obtain from (40),

$$(42)\quad \begin{cases} \tfrac{1}{2}(H'_1+H'_2)=H_0+K_0+K_3\cos 3\,\Delta'\cos 3\,q_2-K_3\sin 3\,\Delta'\sin 3\,q_1 \\ \tfrac{1}{2}(H'_1-H'_2)=K_2-K_3\cos 3\,\Delta'\cos 3\,q_2-K_3\cos 3\,\Delta'\cos 3\,q_2 \\ \tfrac{1}{2}(H_1-H_3)=K_3\cos 3\,\Delta' \\ \tfrac{1}{2}(H_2-H_4)=K_3\sin 3\,\Delta' \end{cases}$$

and, from (41), omitting $9\,A_3$ in comparison with $4\,A_2$ in these very small quantities,

$$(43)\quad \begin{cases} \sin q_1=-\dfrac{3\,K_3\sin 3\,\Delta'}{4\,K_2} \\ \cos q_2=-\dfrac{3\,K_3\cos 3\,\Delta'}{4\,K_2} \end{cases}$$

Since $\sin q_1=\sin q_3$, and $\sin q_2=\sin q_4$, we have $\Sigma_n\,q_n=\frac{3}{2}\pi$, and hence from the first of (37) we get $L_2=\frac{1}{4}(\Sigma_n\,\lambda_n-\frac{3}{2}\pi)$ when λ_n are all reckoned from the upper transit; but if two of them, as is usual, are reckoned from the lower transit, putting $\pi=12^h\ 25^m.24$ in solar time, we get, since $L_2=B_0$ in this case,

$$(44)\quad B_0=\tfrac{1}{4}(\Sigma_n\,\lambda_n-12^h\ 25^m.24)=\tfrac{1}{2}(\lambda'_1+\lambda'_2-6^h\ 12^m.62)$$

which is the *mean establishment of the port.*

In the first two equations of (40), the terms depending upon A_3 being the products of two factors, which are both generally small, are, for the most part, entirely insensible, and may be omitted. If we then put

H'_0 = the mean height of the sea above the assumed zero plane,

we shall have

$$H'_0 = H_0 + K_0 = \tfrac{1}{2}(H'_1 + H'_2) \tag{45}$$

25. If we obtain the values of λ_n for any values of η_i by grouping the observations in such a manner that all the inequalities belonging to the other arguments are eliminated, we have from (26) for high waters,

$$\lambda'_1 - B_0 - q_1 = \Sigma_i B_i \sin(\eta_i - \varepsilon_i) = \Sigma_i (M_i \sin \eta_i + N_i \cos \eta_i) \tag{46}$$

and for low waters,

$$\lambda'_2 - B_0 - q_2 + k = \Sigma_i B_i \sin(\eta_i - \varepsilon_i) = \Sigma_i (M_i \sin \eta_i + N_i \cos \eta_i) \tag{47}$$

in which

$$B_i = \sqrt{M_i^2 + N_i^2}, \text{ and } \tan \varepsilon_i = -\frac{N_i}{M_i} \tag{48}$$

In these expressions Σ_i includes only the terms the angles of which may be included in the same argument; that is, the angles which are multiples of the first. The value of k in (34) must be used, putting $n = \frac{1}{2}$ and taking only the inequality belonging to η_i.

Having obtained from observations m values of λ'_1 or λ'_2, or of both, corresponding to m values of the argument, the preceding equations give m conditions for determining, by the method of least squares, the value of the constants B_i and ε_i.

If we in like manner obtain the values of H_n for any values of η_i, we obtain from the first and third of (40), omitting the small terms just referred to (§ 24),

$$H'_1 - H_0 = A_0 + A_2 \text{ for high waters,}$$

and from the second and fourth of (40),

$$H'_2 - H_0 = A_0 - A_2 \text{ for low waters.}$$

But in this case we have (24),

$$A_0 = K_0 + K_0 \Sigma_i R_i \cos(\eta_i - a_i) = K_0 + K_0 \Sigma_i (M_i \cos \eta_i + N_i \sin \eta_i)$$
$$A_2 = K_2 + K_2 \Sigma_i R_i \cos(\eta_i - a_i) = K_2 + K_2 \Sigma_i (M_i \cos \eta_i + N_i \sin \eta_i)$$

in which Σ_i is limited as above, and in which

$$R_i = \sqrt{M_i^2 + N_i^2}, \text{ and } \tan a_i = \frac{N_i}{M_i} \tag{49}$$

The values of R_i, M_i, &c., differ in their different connections with K_0 and K_2. From the preceding we get, for high waters,

$$\left\{\begin{array}{l} H'_1 - H'_0 - K_2 = K_0 \Sigma_i (M_i \cos \eta_i + N_i \sin \eta_i) + K_2 \Sigma_i (M_i \cos \eta_i + N_i \sin \eta_i) \\ H'_2 - H'_0 + K_2 = K_0 \Sigma_i (M_i \cos \eta_i + N_i \sin \eta_i) - K_2 \Sigma_i (M_i \cos \eta_i + N_i \sin \eta_i) \end{array}\right. \tag{50}$$

With m values of H'_1 and H'_2, corresponding to m values of the argument, we have, from the preceding, m equations of condition for determining the constants $R_{(s,i)}$ and $a_{(s,i)}$.

From the first of (37) and from (41) we obtain, when λ_3 and λ_4 are reckoned from the lower transit,

$$\left\{\begin{array}{l} \frac{1}{2}(\lambda_1 - \lambda_3) = \sin q_1 \\ \frac{1}{2}(\lambda_2 - \lambda_4) = -\cos q_2 \end{array}\right. \tag{51}$$

when A_1 is small in comparison with A_2.

We also obtain from (40), in the case in which A_1 is not eliminated in the grouping of the observations,

$$\left\{\begin{array}{l} \frac{1}{2}(H_1 - H_3) = A_1 \cos \Delta + A_3 \cos 3\Delta \\ \frac{1}{2}(H_2 - H_4) = -A_1 \sin \Delta + A_3 \sin 3\Delta \end{array}\right. \tag{52}$$

In these equations A_3 is always so small that the values of K_3 and Δ', obtained by the last two conditions of (42) for the constant and principal part of A_3, can be used without any sensible error.

With m values of λ_n for both high and low waters of both transits, (51) and (41) give m equa-

tions of condition for determining A_1 and Δ for m values of $\varphi = \frac{1}{2}\eta_3$, when A_2 and A_3 and also Δ' have been determined from preceding conditions.

With m values of H_n, also, for both high and low waters of both transits, (52) gives, when A_3 and Δ' are known or insensible, m equations of condition for determining A_1 and Δ for m values of φ from observations of the heights only.

From (32) we have

(53) $$A_1 = K_1 \sin(\varphi - \alpha) = M \sin\varphi + N \cos\varphi$$

in which

(54) $$K_1 = \sqrt{M^2 + N^2}, \text{ and } \tan\alpha = -\frac{N}{M}$$

With m values of A_1, determined by the preceding equations, (53) gives m equations of condition for determining R and ϵ.

From the first of (41) we obtain, approximately, when A_1 is small in comparison with A_2, and consequently sin q is small,

$$q_1 = -\frac{A_1 \sin\Delta}{4\,A_2}$$

and from the second of (41),

$$q_2 - \tfrac{1}{2}\pi = -\frac{A_1 \cos\Delta}{4\,A_2}$$

When q_1 and $q_2 - \frac{1}{2}\pi$ are very small we can use for A_2 its mean value K_2, and then with the preceding value of A_1 we get

(55) $$\begin{cases} q_1 = -\dfrac{K_1 \sin\Delta}{4\,K_2} \sin(\varphi - \alpha) \\ q_2 - \frac{1}{2}\pi = -\dfrac{K_1 \cos\Delta}{4\,K_2} \sin(\varphi - \alpha) \end{cases}$$

The values of q_3 and q_4 are the complements of the preceding expressions respectively.

TABLES OF AVERAGE OR NORMAL VALUES.

26. The following tables contain the averages of groups of observations taken within certain limits of two arguments, and arranged, with reference to the averages of the arguments to which the observations correspond, in the form of tables of double entry. By summing these average results in two ways, the averages of all the observations contained within the limits of each group of either argument are obtained. The arguments have been for the most part divided into twenty-four equal parts, and the mean of the two limits of each division has been taken as the average of the values of the arguments, except in the case of $(\psi - \psi')$, in which the true average has been obtained. From these tabular results all the constants in this discussion have been obtained, and they might be treated in various other ways and many important results obtained which have not been brought out here.

An explanation of the notation contained in the headings of these tables may be found in sections (4), (8), and (11). The values of all the arguments except η_2 are given for the time of the moon's apparent transit over the Washington meridian, happening a little more than two days before the time of high water, and which is the transit C according to Lubbock's notation. For the sake of convenience in grouping the observations, the values of η_2 were used for a time two lunar days later, for which a reduction must be made when it is necessary to have the values of the arguments all referred to the same time.

To these tabular values a constant of 2 days must be added to the lunitidal intervals, and also 20 feet to the heights of high water, and 10 feet to those of low water, for the absolute heights above the assumed zero of the tide-gauge.

TABLE I—*Containing average values belonging to the Arguments* $(\psi - \psi') = \frac{1}{2}\eta_1$ *and* $\phi = \frac{1}{2}\eta_3$.

UPPER TRANSITS.

ϕ	$(\psi-\psi') = 0h.\ 0m.\ \ldots\ 0h.\ 30m.$						$(\psi-\psi') = 0h.\ 30m.\ \ldots\ 1h.\ 0m.$						$(\psi-\psi') = 1h.\ 0m.\ \ldots\ 1h.\ 30m.$					
	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2
°		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*
7.5	12	0 12	0 40	6 47	5.60	4.58	14	0 43	0 33	6 43	5.62	4.48	15	1 16	0 26	6 38	5.40	4.94
22.5	14	0 12	0 43	6 46	5.16	4.87	13	0 45	0 39	6 45	5.38	4.92	12	1 22	0 31	6 40	5.14	5.03
37.5	15	0 16	0 45	6 49	5.41	5.15	14	0 53	0 38	6 44	4.88	5.19	10	1 14	0 34	6 42	5.33	4.80
52.5	12	0 17	0 46	6 51	5.41	5.03	10	0 42	0 38	6 42	5.04	5.47	12	1 13	0 35	6 42	5.32	5.22
67.5	9	0 16	0 43	6 50	5.17	5.17	10	0 42	0 41	6 44	5.19	5.06	10	1 16	0 33	6 40	5.01	4.91
82.5	12	0 11	0 45	6 48	5.27	4.97	11	0 41	0 39	6 46	4.89	5.06	10	1 14	0 32	6 43	5.15	5.16
97.5	11	0 17	0 40	6 46	5.10	5.21	11	0 47	0 34	6 43	5.04	5.17	10	1 16	0 30	6 34	4.69	5.47
112.5	9	0 13	0 40	6 45	4.98	5.00	10	0 47	0 28	6 35	5.07	4.94	11	1 16	0 29	6 37	5.19	5.21
127.5	10	0 16	0 33	6 43	5.20	4.63	11	0 41	0 34	6 42	5.12	4.98	9	1 11	0 31	6 39	5.08	5.07
142.5	14	0 11	0 35	6 46	5.44	4.52	12	0 47	0 32	6 38	4.96	4.79	11	1 16	0 32	6 42	5.39	4.59
157.5	12	0 18	0 39	6 51	5.53	4.70	11	0 49	0 30	6 38	5.41	4.62	10	1 15	0 31	6 42	5.30	4.37
172.5	13	0 17	0 40	6 52	5.62	4.54	12	0 47	0 36	6 46	5.72	4.59	10	1 13	0 29	6 37	5.62	4.64
187.5	13	0 17	0 41	6 53	5.91	4.71	13	0 49	0 37	6 47	5.94	4.63	12	1 16	0 35	6 46	5.75	4.32
202.5	11	0 19	0 40	6 53	5.82	4.16	12	0 46	0 36	6 47	6.07	4.36	11	1 14	0 33	6 48	5.55	4.51
217.5	12	0 17	0 41	6 56	6.26	4.03	12	0 42	0 38	6 53	5.79	4.55	13	1 15	0 39	6 50	5.72	4.54
232.5	8	0 13	0 47	7 02	6.07	4.41	13	0 45	0 38	6 53	6.01	4.51	12	1 17	0 33	6 46	5.89	4.87
247.5	11	0 12	0 49	7 00	6.23	4.25	10	0 44	0 38	6 52	5.63	4.80	11	1 11	0 34	6 50	6.10	4.52
262.5	12	0 16	0 42	6 56	5.74	4.62	12	0 45	0 34	6 49	6.05	4.40	9	1 14	0 31	6 44	5.67	4.63
277.5	10	0 15	0 37	6 51	5.91	4.15	11	0 47	0 36	6 52	5.82	4.62	10	1 12	0 38	6 50	5.67	4.70
292.5	10	0 11	0 34	6 50	5.95	4.05	12	0 42	0 30	6 43	5.66	4.65	11	1 14	0 26	6 41	5.89	4.28
307.5	11	0 12	0 38	6 54	6.01	4.42	9	0 43	0 34	6 47	5.91	4.28	9	1 15	0 29	6 40	5.67	4.22
322.5	10	0 17	0 34	6 45	6.12	4.54	11	0 41	0 29	6 43	5.88	4.45	10	1 8	0 22	6 33	5.46	4.39
337.5	10	0 20	0 37	6 46	5.60	4.14	10	0 45	0 28	6 38	5.73	4.31	13	1 12	0 22	6 34	5.74	4.66
352.5	13	0 19	0 38	6 45	5.59	4.09	11	0 42	0 29	6 39	5.53	4.14	13	1 15	0 28	6 37	5.39	4.55
	273	0 15.2	0 40.3	6 50.3	5.63	4.58	275	0 44.8	0 34.6	6 44.5	5.51	4.71	264	1 14.4	0 30.9	6 41.4	5.46	4.73

ϕ	$(\psi-\psi') = 1h.\ 30m.\ \ldots\ 2h.\ 0m.$						$(\psi-\psi') = 2h.\ 0m.\ \ldots\ 2h.\ 30m.$						$(\psi-\psi') = 2h.\ 30m.\ \ldots\ 3h.\ 0m.$					
	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2
°		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*
7.5	12	1 51	0 26	6 35	5.10	4.84	10	2 11	0 22	6 31	5.00	5.24	11	2 41	0 21	6 31	5.34	5.51
22.5	11	1 46	0 25	6 34	5.08	4.65	12	2 16	0 25	6 34	4.93	5.26	13	2 45	0 25	6 35	4 97	5.24
37.5	9	1 40	0 33	6 41	5.42	4.94	13	2 13	0 26	6 33	4.84	5.76	14	2 47	0 23	6 33	4.73	5.56
52.5	14	1 44	0 29	6 40	4.71	5.31	14	2 20	0 28	6 37	4.70	5.70	12	2 48	0 23	6 30	4.52	5.62
67.5	11	1 45	0 26	6 35	4.79	5.51	12	2 16	0 26	6 34	4.80	5.90	12	2 41	0 24	6 33	4.44	5.65
82.5	12	1 43	0 31	6 35	5.13	5.68	12	2 17	0 26	6 33	4.74	5.69	12	2 49	0 19	6 27	4.44	5.97
97.5	10	1 43	0 32	6 37	4.56	5.24	10	2 15	0 25	6 34	5.34	5.50	10	2 43	0 23	6 30	4.87	5.94
112.5	12	1 46	0 27	6 38	4.98	5.38	9	2 16	0 20	6 28	4.74	5.58	10	2 41	0 16	6 25	4.59	5.38
127.5	11	1 46	0 20	6 28	5.04	5.04	11	2 16	0 16	6 25	4.72	5.21	10	2 43	0 19	6 29	4.95	5.38
142.5	10	1 42	0 20	6 28	5.29	4.88	12	2 13	0 21	6 26	4.87	5.02	10	2 46	0 18	6 30	4.76	5.23
157.5	12	1 43	0 31	6 38	5.10	4.91	12	2 11	0 25	6 34	4.95	4.91	9	2 40	0 23	6 32	5.16	5.79
172.5	13	1 42	0 28	6 38	5.29	4.82	12	2 17	0 23	6 33	5.06	5.05	12	2 51	0 25	6 33	5.06	5.21
187.5	14	1 43	0 26	6 39	5.52	4.56	13	2 15	0 27	6 40	5.18	5.03	12	2 44	0 25	6 37	5.31	5.23
202.5	12	1 45	0 30	6 42	5.54	4.90	14	2 19	0 28	6 40	5.16	4.98	12	2 48	0 22	6 35	5.12	5.15
217.5	13	1 48	0 27	6 41	5.50	4.70	11	2 20	0 28	6 38	5.52	5.11	11	2 42	0 23	6 40	5.47	5.09
232.5	14	1 43	0 30	6 49	5.58	5.00	14	2 12	0 30	6 41	5.48	5.09	12	2 43	0 25	6 42	5.32	4.93
247.5	12	1 44	0 31	6 44	5.67	4.92	14	2 15	0 28	6 39	5.34	5.29	13	2 45	0 23	6 37	5.44	5.33
262.5	11	1 44	0 27	6 43	5.61	5.17	12	2 16	0 21	6 35	5.71	5.15	10	2 40	0 23	6 41	5.59	5.24
277.5	11	1 44	0 25	6 38	5.55	4.85	10	2 14	0 21	6 37	5.77	4.94	11	2 44	0 21	6 36	5.19	5.38
292.5	12	1 44	0 17	6 33	5.64	4.46	12	2 14	0 24	6 30	5.77	4.55	11	2 52	0 18	6 34	5.19	4.80
307.5	11	1 45	0 21	6 35	5.63	4.83	11	2 19	0 15	6 38	5.63	5.03	11	2 44	0 17	6 30	5.17	5.02
322.5	11	1 42	0 24	6 38	5.73	4.70	12	2 14	0 26	6 38	5.46	4.86	11	2 43	0 15	6 27	5.19	5.08
337.5	12	1 45	0 22	6 33	5.57	4.68	10	2 20	0 23	6 36	5.71	4.85	10	2 47	0 13	6 27	5.35	5.22
352.5	12	1 49	0 25	6 36	5.42	4.92	11	2 15	0 20	6 33	5.44	4.92	10	2 42	0 13	6 25	5.08	5.32
	285	1 44.4	0 26.4	6 37.4	5.31	4.95	283	2 15.6	0 23.9	6 34.4	5.20	5.19	269	2 44.6	0 20.7	6 32.4	5.05	5.32

TABLE I—*Containing average values belonging to the Arguments* $(\psi - \psi') = \frac{1}{2}\,\eta_1$ *and* $\phi = \frac{1}{2}\,\eta_3$—Continued.

UPPER TRANSITS.

ϕ	$(\psi-\psi') = 3h.\ 0m.$ . . . . $3h.\ 30m.$						$(\psi-\psi') = 3h.\ 30m.$ . . . . $4h.\ 0m.$						$(\psi-\psi') = 4h.\ 0m.$ . . . . $4h.\ 30m.$					
	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H^2	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2
°		h. m.	h. m.	h. m.	Ft.	Ft.		h. m.	h. m.	h. m.	Ft.	Ft.		h. m.	h. m.	h. m.	Ft.	Ft.
7.5	12	3 13	0 19	6 30	4.92	5.44	10	3 44	0 26	6 32	4.54	5.64	11	4 12	0 25	6 35	4.23	5.70
22.5	12	3 18	0 22	6 32	4.39	5.46	11	3 45	0 19	6 32	4.66	5.78	12	4 12	0 28	6 38	4.18	5.80
37.5	12	3 19	0 25	6 34	4.46	5.67	11	3 45	0 22	6 32	4.38	5.66	11	4 12	0 26	6 41	4.40	5.83
52.5	10	3 17	0 21	6 34	4.68	5.78	12	3 42	0 23	6 33	3.72	5.86	14	4 17	0 31	6 38	3.97	6.14
67.5	14	3 16	0 25	6 32	4.53	6.12	13	3 44	0 23	6 33	4.41	6.08	12	4 20	0 26	6 34	3.68	6.33
82.5	12	3 16	0 18	6 31	4.93	5.64	11	3 44	0 19	6 27	4.28	6.08	12	4 13	0 21	6 28	4.10	6.87
97.5	11	3 16	0 20	6 30	4.78	5.83	14	3 45	0 16	6 26	4.10	6.18	13	4 21	0 17	6 32	4.01	6.20
112.5	11	3 15	0 17	6 27	4.73	5.87	10	3 45	0 22	6 31	4.83	5.95	12	4 14	0 22	6 31	4.59	6.30
127.5	11	3 15	0 11	6 24	4.62	5.64	10	3 42	0 14	6 21	4.18	5.74	10	4 17	0 23	6 36	4.66	6.00
142.5	12	3 13	0 15	6 23	4.78	5.68	11	3 47	0 10	6 27	4.83	5.57	12	4 16	0 19	6 31	4.45	5.58
157.5	11	3 13	0 20	6 29	4.84	5.46	11	3 44	0 20	6 28	4.73	6.04	12	4 14	0 27	6 40	4.85	5.57
172.5	10	3 23	0 23	6 36	4.83	5.54	11	3 45	0 26	6 35	4.85	5.45	11	4 15	0 26	6 41	4.68	5.85
187.5	11	3 12	0 22	6 31	4.91	5.39	11	3 40	0 26	6 39	4.89	5.73	11	4 15	0 27	6 45	5.03	5.57
202.5	12	3 14	0 22	6 39	5.14	5.46	13	3 47	0 29	6 43	4.99	5.86	13	4 16	0 31	6 44	4.87	5.78
217.5	13	3 14	0 25	6 40	5.07	5.37	13	3 42	0 24	6 41	5.01	5.77	12	4 16	0 33	6 50	4.79	5.85
232.5	14	3 17	0 26	6 41	5.17	5.73	13	3 44	0 27	6 42	4.90	5.45	11	4 15	0 30	6 45	5.03	5.83
247.5	12	3 22	0 26	6 47	5.42	5.25	13	3 43	0 22	6 36	4.86	5.90	15	4 14	0 25	6 47	5.06	5.96
262.5	12	3 9	0 24	6 37	5.15	5.43	14	3 45	0 20	6 37	5.12	5.64	12	4 22	0 30	6 44	4.61	5.90
277.5	13	3 16	0 17	6 33	6.30	5.48	11	3 45	0 17	6 33	5.17	5.75	12	4 16	0 19	6 36	4.79	5.62
292.5	9	3 15	0 15	6 28	5.63	5.42	10	3 42	0 13	6 31	5.13	5.96	12	4 16	0 15	6 26	5.12	5.84
307.5	12	3 18	0 16	6 28	5.14	5.36	12	3 45	0 16	6 28	5.19	5.22	11	4 15	0 11	6 31	4.86	5.85
322.5	12	3 17	0 10	6 21	5.08	5.22	12	3 44	0 17	6 32	4.80	5.12	10	4 19	0 13	6 30	4.91	5.72
337.5	11	3 13	0 18	6 27	4.95	5.33	11	3 45	0 20	6 32	5.19	5.40	11	4 17	0 15	6 30	4.62	5.46
362.5	11	3 17	0 17	6 29	4.66	5.61	12	3 47	0 17	6 32	4.92	5.35	11	4 17	0 16	6 28	4.56	5.69
	280	3 15.8	0 19.8	6 31.8	4.92	5.55	280	3 44.2	0 20.3	6 32.6	4.74	5.71	283	4 15.9	0 23.2	6 36.7	4.58	5.88

ϕ	$(\psi-\psi') = 4h.\ 30m.$ . . . . $5h.\ 0m.$						$(\psi-\psi') = 5h.\ 0m.$ . . . . $5h.\ 30m.$						$(\psi-\psi') = 5h.\ 30m.$ . . . . $6h.\ 0m.$					
	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2
°		h. m.	h. m.	h. m.	Ft.	Ft.		h. m.	h. m.	h. m.	Ft.	Ft.		h. m.	h. m.	h. m.	Ft.	Ft.
7.5	12	4 45	0 31	6 43	4.43	5.68	11	5 15	0 33	6 45	4.21	5.72	10	5 44	0 42	6 53	4.27	5.72
22.5	11	4 43	0 35	6 46	4.60	5.66	12	5 16	0 36	6 49	4.10	6.20	10	5 42	0 38	6 52	4.33	5.94
37.5	16	4 46	0 31	6 42	4.03	6.05	11	5 18	0 41	6 53	4.21	6.28	10	5 46	0 44	6 53	4.34	5.90
52.5	12	4 47	0 32	6 42	3.89	6.02	11	5 14	0 40	6 51	4.03	5.95	12	5 39	0 46	6 54	3.78	6.43
67.5	12	4 46	0 30	6 42	3.93	5.88	12	5 16	0 39	6 47	3.68	6.37	13	5 43	0 46	6 58	3.62	5.93
82.5	14	4 43	0 27	6 37	4.27	6.43	13	5 17	0 35	6 45	3.92	6.49	13	5 46	0 38	6 50	3.70	6.04
97.5	11	4 47	0 20	6 28	4.00	6.33	12	5 16	0 27	6 42	4.43	6.43	14	5 43	0 36	6 46	4.01	6.57
112.5	12	4 42	0 20	6 30	4.61	5.91	12	5 16	0 26	6 40	4.05	6.55	13	5 46	0 29	6 44	4.35	6.33
127.5	12	4 46	0 19	6 28	4.32	6.53	11	5 18	0 23	6 37	4.24	6.22	11	5 42	0 29	6 41	4.38	6.12
142.5	11	4 45	0 20	6 31	4.43	6.15	11	5 17	0 28	6 42	4.72	5.89	12	5 41	0 32	6 46	4.40	6.20
157.5	12	4 46	0 20	6 35	4.31	6.06	10	5 13	0 29	6 44	4.74	5.62	11	5 43	0 34	6 49	4.73	6.01
172.5	9	4 45	0 31	6 45	4.48	5.49	11	5 16	0 29	6 46	4.70	5.94	11	5 45	0 40	6 57	4.89	5.90
187.5	11	4 44	0 32	6 43	4.47	5.59	11	5 15	0 32	6 51	4.61	5.57	11	5 44	0 40	6 56	5.03	5.94
202.5	11	4 47	0 40	6 52	4.85	5.41	10	5 14	0 41	6 58	4.67	5.80	11	5 46	0 48	6 59	4.83	5.77
217.5	13	4 42	0 36	6 50	4.69	5.76	12	5 17	0 41	7 0	4.56	5.40	12	5 44	0 51	7 8	5.06	6.14
232.5	12	4 47	0 30	6 51	4.84	5.85	14	5 16	0 48	7 5	4.75	6.01	12	5 47	0 47	7 7	4.86	5.82
247.5	13	4 44	0 33	6 49	4.58	6.09	12	5 18	0 35	6 58	4.97	5.90	14	5 45	0 47	7 12	4.70	6.42
262.5	12	4 39	0 22	6 41	4.87	6.19	13	5 12	0 37	6 55	4.71	5.91	15	5 40	0 35	6 55	4.95	6.15
277.5	15	4 45	0 24	6 44	4.87	5.84	14	5 19	0 32	6 51	4.58	6.07	12	5 47	0 36	6 56	5.05	6.31
292.5	11	4 45	0 16	6 34	4.79	6.02	12	5 12	0 21	6 41	4.80	5.99	13	5 44	0 33	6 52	5.43	5.84
307.5	10	4 44	0 17	6 32	4.84	5.72	12	5 16	0 25	6 42	4.69	5.83	13	5 45	0 27	6 44	4.51	6.11
322.5	10	4 45	0 19	6 35	4.79	5.68	12	5 16	0 19	6 36	4.52	5.82	11	5 50	0 28	6 43	4.29	5.72
337.5	11	4 47	0 22	6 39	4.72	5.75	12	5 13	0 29	6 45	4.69	5.78	11	5 44	0 29	6 43	4.35	6.13
352.5	10	4 46	0 28	6 41	4.45	5.85	12	5 13	0 30	6 44	5.05	5.57	13	5 47	0 36	6 49	4.34	5.93
	283	4 44.8	0 26.4	6 40.0	4.50	5.91	283	5 15.6	0 32.3	6 47.8	4.48	5.97	288	5 44.3	0 37.9	6 52.8	4.46	6.06

TABLE I—*Containing average values belonging to the Arguments* $(\psi - \psi') = \frac{1}{2}\eta_1$ and $\phi = \frac{1}{2}\eta_3$—Continued.

UPPER TRANSITS.

ϕ	$(\psi-\psi') = 6h.\ 0m. \ldots 6h.\ 30m.$						$(\psi-\psi') = 6h.\ 30m. \ldots 7h.\ 0m.$						$(\psi-\psi') = 7h.\ 0m. \ldots 7h.\ 30m.$					
	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2
°		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*
7.5	12	6 14	0 46	6 59	4.47	5.93	11	6 45	0 47	7 1	4.48	5.67	11	7 17	1 1	7 6	4.07	5.75
22.5	11	6 10	0 48	6 57	4.32	6.00	12	6 42	0 54	7 6	4.12	5.73	11	7 11	0 57	7 9	4.45	5.52
37.5	11	6 15	0 52	7 1	4.07	6.43	10	6 44	0 58	7 8	3.84	5.93	11	7 17	1 3	7 14	4.25	5.80
52.5	12	6 14	0 56	7 4	3.84	6.17	13	6 46	1 0	7 9	4.30	5.98	11	7 16	1 6	7 14	4.13	6.00
67.5	13	6 19	0 53	7 3	3.52	6.52	12	6 44	0 56	7 11	3.79	5.67	9	7 15	1 9	7 17	4.06	5.85
82.5	13	6 15	0 48	7 1	3.49	6.45	13	6 46	0 57	7 10	3.92	5.84	11	7 19	1 8	7 12	3.60	6.10
97.5	12	6 17	0 44	6 57	4.05	6.43	13	6 43	0 54	7 1	3.89	5.89	11	7 14	1 1	7 10	4.08	6.03
112.5	13	6 18	0 45	6 59	4.11	6.56	14	6 42	0 45	6 58	4.33	6.14	13	7 16	0 57	7 10	4.24	6.28
127.5	12	6 11	0 30	6 43	4.00	6.43	14	6 46	0 47	6 59	4.23	6.13	11	7 22	0 54	7 5	4.45	6.05
142.5	11	6 18	0 40	6 53	4.64	6.02	11	6 45	0 41	6 55	4.48	6.43	11	7 15	0 48	7 4	4.65	5.84
157.5	13	6 12	0 41	6 55	4.69	5.93	12	6 43	0 49	7 3	4.85	5.97	11	7 12	0 51	7 4	4.75	5.50
172.5	13	6 16	0 45	7 0	4.92	5.98	11	6 49	0 50	7 7	4.84	5.56	10	7 14	0 55	7 12	5.25	5.51
187.5	9	6 14	0 47	7 3	4.90	5.80	10	6 48	0 52	7 9	5.07	5.46	10	7 13	0 54	7 14	5.27	5.58
202.5	12	6 14	0 53	7 11	5.20	5.71	11	6 40	0 53	7 11	5.00	6.00	11	7 13	1 5	7 24	5.38	5.53
217.5	11	6 17	1 0	7 16	4.85	5.79	11	6 46	1 1	7 20	4.92	5.60	12	7 14	1 1	7 24	5.20	5.22
232.5	11	6 14	0 59	7 17	4.64	5.73	11	6 41	0 58	7 18	5.04	5.59	11	7 19	1 10	7 28	5.11	5.55
247.5	12	6 15	0 51	7 14	5.12	5.81	12	6 46	1 2	7 24	4.98	5.34	12	7 15	1 7	7 27	4.99	5.84
262.5	12	6 18	0 50	7 12	4.69	6.08	12	6 43	0 50	7 12	4.96	5.90	11	7 11	1 0	7 26	4.84	5.35
277.5	11	6 19	0 48	7 10	4.68	5.94	13	6 43	0 46	7 6	5.19	5.80	13	7 17	1 1	7 21	4.72	5.54
292.5	11	6 15	0 42	6 59	4.44	6.04	12	6 46	0 46	7 4	4.65	5.72	10	7 18	0 56	7 12	4.85	5.69
307.5	12	6 17	0 37	6 56	4.94	5.93	11	6 38	0 44	7 5	4.61	5.61	12	7 12	0 45	7 7	4.89	5.67
322.5	10	6 16	0 37	6 53	4.68	6.00	11	6 47	0 37	6 55	4.75	5.58	13	7 17	0 54	7 7	4.65	5.67
337.5	11	6 16	0 35	6 49	4.41	5.57	13	6 42	0 42	6 59	4.43	5.72	14	7 16	0 49	7 3	4.61	5.63
352.5	9	6 18	0 34	6 50	4.31	5.51	10	6 47	0 48	7 0	4.20	5.64	11	7 16	0 51	7 5	4.37	5.67
	276	6 15.5	0 45.9	7 0.9	4.46	6.03	283	6 44.2	0 50.8	7 6.3	4.54	5.79	271	7 15.4	0 58.4	7 13.1	4.62	5.72

ϕ	$(\psi-\psi') = 7h.\ 30m. \ldots 8h.\ 0m.$						$(\psi-\psi)' = 8h.\ 0m. \ldots 8h.\ 30m.$						$(\psi-\psi') = 8h.\ 30m. \ldots 9h.\ 0m.$					
	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2
°		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*
7.5	10	7 49	0 59	7 11	4.32	5.60	11	8 19	1 6	7 14	4.41	5.19	13	8 45	1 9	7 14	5.00	5.13
22.5	12	7 47	1 1	7 13	4.65	5.54	11	8 15	1 7	7 15	4.53	5.54	11	8 48	1 4	7 14	5.44	5.24
37.5	10	7 43	1 8	7 19	4.27	5.64	10	8 13	1 11	7 19	4.12	5.54	11	8 44	1 5	7 15	4.71	5.36
52.5	11	7 47	1 6	7 16	4.44	5.71	9	8 16	1 15	7 19	4.47	5.85	10	8 43	1 8	7 15	4.78	5.21
67.5	11	7 43	1 3	7 12	4.35	5.85	11	8 15	1 7	7 17	4.61	5.53	11	8 42	1 11	7 15	4.47	5.33
82.5	11	7 44	1 4	7 17	4.24	5.60	13	8 12	1 16	7 22	4.08	5.87	13	8 44	1 1	7 11	4.62	5.41
97.5	12	7 43	1 1	7 13	4.34	5.53	13	8 16	1 11	7 18	3.99	5.54	12	8 47	1 7	7 14	4.50	5.17
112.5	14	7 43	0 59	7 10	4.28	5.72	12	8 20	1 3	7 14	4.34	5.66	13	8 44	1 6	7 14	4.67	5.13
127.5	12	7 45	0 59	7 9	4.60	5.66	13	8 12	1 0	7 11	4.64	5.51	14	8 43	1 1	7 11	4.59	5.10
132.5	14	7 40	0 54	7 5	4.82	5.58	14	8 17	1 4	7 15	4.73	5.38	14	8 46	1 3	7 12	5.04	5.08
157.5	11	7 43	0 58	7 12	5.14	5.94	12	8 17	1 2	7 14	5.09	5.20	11	8 46	0 58	7 9	5.29	5.01
172.5	12	7 45	0 59	7 15	4.73	5.56	10	8 20	1 2	7 17	5.43	5.06	10	8 44	1 9	7 26	5.64	5.32
187.5	13	7 45	1 0	7 21	5.31	5.19	12	8 16	1 5	7 21	5.26	5.06	9	8 47	1 8	7 21	5.76	5.02
202.5	12	7 41	1 3	7 21	5.34	5.26	12	8 16	1 3	7 23	5.52	4.81	11	8 43	1 12	7 27	5.67	4.94
217.5	10	7 47	1 7	7 27	5.45	5.48	11	8 14	1 10	7 26	5.59	4.97	10	8 43	1 2	7 19	6.08	4.43
242.5	12	7 47	1 9	7 28	5.63	5.08	11	8 19	1 13	7 31	5.35	4.95	11	8 47	1 13	7 31	5.58	5.05
247.5	10	7 42	1 9	7 31	5.13	5.01	12	8 13	1 13	7 27	5.28	5.51	11	8 45	1 10	7 27	6.21	4.90
262.5	14	7 41	1 9	7 26	5.09	5.08	12	8 17	1 9	7 31	5.24	5.12	10	8 46	1 2	7 21	5.78	5.14
277.5	13	7 41	1 1	7 20	4.93	5.44	11	8 17	1 3	7 23	5.15	4.76	13	8 43	1 7	7 25	5.40	4.52
292.5	13	7 46	0 58	7 18	5.26	5.30	13	8 17	1 3	7 18	5.12	5.25	12	8 46	1 9	7 24	5.51	4.66
307.5	14	7 42	0 52	7 13	5.07	5.70	14	8 18	1 3	7 19	4.93	5.15	13	8 45	0 56	7 12	5.65	4.78
322.5	11	7 46	0 58	7 12	4.95	5.48	11	8 16	0 57	7 9	5.05	5.73	12	8 41	0 56	7 9	5.68	5.07
337.5	13	7 46	0 51	7 8	4.77	5.29	12	8 12	0 59	7 11	5.06	5.30	13	8 44	0 58	7 13	5.25	5.36
352.5	9	7 46	0 57	7 9	4.91	5.44	11	8 12	1 0	7 11	4.97	5.36	12	8 43	1 2	7 12	4.94	5.26
	284	7 44.2	1 1.0	7 16.1	4.84	5.49	281	8 15.8	1 5.9	7 18.6	4.87	5.33	280	8 44.5	1 4.8	7 17.1	5.22	5.06

TABLE I—*Containing average values belonging to the Arguments* $(\psi - \psi') = \frac{1}{2}\eta_1$ and $\phi = \frac{1}{2}\eta_3$—Continued.

UPPER TRANSITS.

ϕ	$(\psi-\psi') = 9h.\ 0m.$ . . . . $9h.\ 30m.$						$(\psi-\psi') = 9h.\ 30m.$ . . . . $10h.\ 0m.$						$(\psi-\psi') = 10h.\ 0m.$ . . . . $10h.\ 30m.$					
	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2
°		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*
7.5	11	9 18	0 58	7 5	5.25	4.56	11	9 43	1 1	7 11	5.65	5.01	12	10 11	1 2	7 7	5.26	5.18
22.5	11	9 17	1 5	7 13	4.92	5.05	10	9 44	1 2	7 9	5.18	4.98	12	10 13	0 59	7 9	5.10	5.06
37.5	10	9 18	1 11	7 14	4.78	5.07	10	9 40	1 5	7 13	4.58	5.06	12	10 11	1 3	7 10	5.39	5.24
52.5	11	9 13	1 16	7 21	4.63	5.41	10	9 44	1 8	7 14	5.01	5.27	14	10 16	1 2	7 8	4.84	5.42
67.5	12	9 15	1 8	7 9	4.68	5.46	12	9 46	1 6	7 10	4.83	5.12	11	10 17	1 4	7 11	5.10	5.21
82.5	11	9 16	1 12	7 15	4.85	5.36	10	9 46	1 3	7 5	4.68	4.83	10	10 15	1 0	7 5	4.83	5.19
97.5	10	9 13	1 6	7 14	4.54	5.34	11	9 42	0 55	7 5	5.08	5.02	12	10 14	1 1	7 5	5.00	5.20
112.5	12	9 17	1 3	7 12	4.44	5.04	12	9 47	0 59	7 7	4.90	5.12	11	10 17	0 58	7 3	4.74	5.08
127.5	10	9 19	1 6	7 14	4.61	5.46	12	9 46	1 1	7 6	5.26	4.56	12	10 12	0 56	7 5	5.04	4.78
142.5	12	9 17	0 58	7 6	5.28	5.08	12	9 42	1 0	7 9	5.32	4.72	13	10 12	0 59	7 6	5.25	5.11
157.5	15	9 14	1 2	7 14	5.36	4.88	13	9 43	0 57	7 11	5.52	4.90	12	10 20	0 56	7 5	5.47	4.92
172.5	13	9 11	0 59	7 16	5.55	4.65	14	9 47	1 0	7 13	5.54	5.03	14	10 17	0 58	7 9	5.65	4.23
187.5	12	9 12	1 5	7 19	5.73	4.86	11	9 45	1 9	7 21	5.75	4.77	12	10 17	1 0	7 16	6.03	4.19
202.5	12	9 14	1 5	7 17	5.78	5.02	11	9 50	1 6	7 24	5.94	4.90	10	10 16	1 0	7 14	6.04	4.57
217.5	12	9 12	1 13	7 27	5.36	4.96	12	9 46	1 8	7 23	5.93	4.48	10	10 16	1 2	7 15	6.21	4.32
232.5	12	9 16	1 6	7 22	6.12	4.36	12	9 48	1 5	7 21	5.97	4.74	10	10 17	1 5	7 18	6.02	4.61
247.5	10	9 13	1 12	7 32	5.29	4.97	11	9 43	1 3	7 22	6.23	4.10	12	10 15	1 1	7 16	5.90	4.45
262.5	10	9 16	1 3	7 25	5.83	4.64	11	9 44	1 4	7 23	5.72	4.70	10	10 15	1 1	7 18	5.51	4.71
277.5	11	9 16	1 4	7 25	5.27	4.76	11	9 48	0 58	7 13	5.91	4.94	8	10 14	0 56	7 12	6.09	5.09
292.5	11	9 17	1 2	7 18	5.74	4.42	11	9 41	1 0	7 14	5.63	4.30	11	10 13	0 55	7 8	5.63	4.39
307.5	12	9 12	0 57	7 16	5.53	4.77	12	9 41	0 59	7 14	5.98	4.27	13	10 16	0 55	7 9	5.63	4.37
322.5	16	9 13	1 1	7 12	5.16	4.65	15	9 46	0 57	7 10	5.76	4.84	12	10 16	0 53	7 10	5.95	4.57
337.5	14	9 19	1 3	7 12	5.27	5.01	12	9 52	0 52	7 4	5.43	4.49	11	10 19	0 57	7 10	5.73	4.43
352.5	12	9 18	1 1	7 12	5.08	4.89	10	9 44	0 58	7 7	5.60	4.86	11	10 12	0 55	7 5	5.63	4.97
	282	9 15.2	1 4.8	7 16.2	5.21	4.94	276	9 44.9	1 1.5	7 12.9	5.49	4.79	275	10 15.0	0 59.1	7 9.8	5.50	4.80

ϕ	$(\psi-\psi') = 10h.\ 30m.$ . . . . $11h.\ 0m.$						$(\psi-\psi') = 11h.\ 0m.$ . . . . $11h.\ 0m.$						$(\psi-\psi') = 11h.\ 30m.$ . . . . $12h.\ 0m.$					
	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2	Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2
°		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*
7.5	14	10 45	0 54	7 4	5.57	5.30	13	11 19	0 50	6 59	5.66	4.66	10	11 46	0 47	6 55	5.84	4.29
22.5	13	10 45	0 56	7 1	5.38	5.04	11	11 19	0 52	6 58	5.32	4.87	10	11 43	0 41	6 58	5.58	4.78
37.5	10	10 48	0 53	7 3	5.41	4.76	10	11 13	0 50	6 57	5.49	4.56	12	11 40	0 52	6 54	5.32	5.21
52.5	8	10 47	0 58	7 5	5.36	4.75	9	11 13	0 53	6 58	5.53	4.62	11	11 43	0 50	6 55	5.28	4.91
67.5	11	10 43	0 59	7 5	5.21	4.92	12	11 12	0 54	6 59	4.94	4.95	10	11 46	0 49	6 53	4.83	5.25
82.5	10	10 44	0 56	6 58	5.06	5.17	9	11 15	0 54	6 58	5.05	5.04	9	11 42	0 50	6 55	5.03	5.22
97.5	10	10 46	0 54	7 0	4.92	4.89	10	11 14	0 48	6 51	4.85	5.11	10	11 44	0 44	6 48	5.15	5.02
112.5	11	10 43	0 49	6 57	5.44	4.83	11	11 16	0 46	6 54	5.35	5.04	11	11 47	0 44	6 45	5.15	4.77
127.5	15	10 44	0 50	7 0	5.28	4.63	13	11 18	0 45	6 55	5.08	4.62	10	11 49	0 45	6 50	5.50	4.70
142.5	13	10 44	0 50	6 57	5.42	4.46	10	11 18	0 40	6 51	5.42	4.45	9	11 41	0 42	6 50	5.62	4.47
157.5	12	10 47	0 51	7 1	5.86	4.41	13	11 17	0 47	6 58	5.47	4.49	13	11 44	0 42	6 50	5.79	4.14
172.5	11	10 46	0 53	7 4	5.98	4.66	12	11 13	0 49	7 0	5.74	4.24	13	11 44	0 47	6 59	5.82	4.60
187.5	13	10 43	0 53	7 7	6.06	4.17	14	11 13	0 55	7 6	6.29	4.14	13	11 46	0 44	6 55	5.81	4.51
202.5	13	10 42	0 58	7 13	6.25	4.17	13	11 15	0 54	7 9	6.43	4.06	13	11 48	0 49	7 1	5.88	4.30
217.5	9	10 40	1 1	7 15	5.97	4.55	11	11 15	0 54	7 10	6.02	4.55	12	11 45	0 48	7 4	6.28	4.20
232.5	11	10 44	1 4	7 17	6.25	4.54	12	11 14	0 56	7 10	6.17	4.39	10	11 46	0 44	7 1	6.14	4.33
247.5	13	10 43	0 58	7 16	6.27	4.13	10	11 18	0 54	7 10	5.82	4.61	11	11 47	0 52	6 59	6.21	4.20
262.5	10	10 48	0 54	7 7	6.51	4.62	12	11 17	0 43	7 0	6.23	4.32	11	11 46	0 46	7 3	6.31	4.14
277.5	11	10 42	0 53	7 10	5.84	4.39	12	11 14	0 50	7 7	5.72	4.18	10	11 45	0 43	6 58	5.82	4.36
292.5	11	10 47	0 48	7 1	5.94	4.98	11	11 13	0 45	7 0	6.19	4.17	10	11 45	0 43	7 4	6.08	4.22
307.5	12	10 43	0 41	7 5	5.66	4.07	10	11 13	0 44	6 53	6.10	4.17	12	11 43	0 38	6 51	5.62	4.64
322.5	12	10 46	0 47	7 3	6.08	3.79	12	11 15	0 43	6 57	5.92	4.27	11	11 44	0 33	6 47	5.73	3.86
337.5	12	10 39	0 49	7 0	5.97	4.24	13	11 14	0 44	6 59	5.78	4.17	14	11 48	0 41	6 49	5.61	4.04
352.5	15	10 45	0 49	7 1	5.63	4.31	15	11 19	0 47	6 54	5.65	4.40	13	11 51	0 45	6 53	5.78	4.41
	280	10 44.3	0 53.7	7 4.3	5.72	4.58	278	11 15.3	0 49.0	6 59.7	5.68	4.50	268	11 45.1	0 45.4	6 55.3	5.67	4.58

TABLE II—*Containing average values belonging to the Arguments* $(\psi-\psi')=\frac{1}{2}\eta_1$ *and* $\phi=\frac{1}{2}\eta_2$.

LOWER TRANSITS.

ϕ	$(\psi-\psi')=0h.\ 0m.$ . . . . $0h.\ 30m.$						$(\psi-\psi')=0h.\ 30m.$ . . . . $1h.\ 0m.$						$(\psi-\psi')=1h.\ 0m.$ . . . . $1h.\ 30m.$					
	Obs.	$(\psi-\psi')$	λ_3	λ_4	H_3	H_4	Obs.	$(\psi-\psi')$	λ_3	λ_4	H_3	H_4	Obs.	$(\psi-\psi')$	λ_3	λ_4	H_3	H_4
°		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*
7. 5	14	0 17	0 40	6 50	5. 67	4. 60	13	0 48	0 33	6 46	5. 87	4. 05	10	1 15	0 28	6 39	5. 91	4. 32
22. 5	11	0 22	0 38	6 51	6. 11	4. 09	11	0 47	0 33	6 47	6. 00	4. 28	13	1 11	0 32	6 44	5. 90	4. 31
37. 5	8	0 17	0 40	6 52	5. 95	4. 31	12	0 41	0 34	6 48	6. 01	4. 51	15	1 15	0 30	6 44	5. 86	4. 58
52. 5	13	0 11	0 39	6 54	6. 11	4. 05	13	0 46	0 35	6 47	6. 08	4. 45	8	1 17	0 30	6 45	6. 02	4. 81
67. 5	10	0 20	0 38	6 54	6. 23	4. 43	11	0 51	0 39	6 50	5. 88	4. 27	10	1 14	0 24	6 42	5. 72	4. 30
82. 5	9	0 14	0 42	6 58	5. 95	4. 49	10	0 43	0 33	6 50	6. 19	4. 18	10	1 14	0 26	6 48	5. 82	4. 52
97. 5	11	0 17	0 38	6 51	6. 31	4. 39	10	0 44	0 34	6 50	6. 18	4. 40	11	1 14	0 30	6 50	5. 62	4. 55
112. 5	12	0 30	0 34	6 48	6. 10	4. 10	11	0 44	0 27	6 43	6. 07	4. 50	11	1 16	0 27	6 38	5. 59	4. 61
127. 5	10	0 20	0 33	6 47	5. 57	4. 30	10	0 48	0 28	6 42	6. 13	4. 25	10	1 15	0 19	6 31	6. 01	4. 36
142. 5	11	0 18	0 38	6 52	5. 93	4. 53	10	0 44	0 33	6 47	5. 49	4. 64	10	1 12	0 29	6 42	5. 58	4. 80
157. 5	12	0 16	0 34	6 47	5. 92	4. 19	12	0 44	0 30	6 43	5. 86	4. 31	13	1 14	0 33	6 46	4. 99	4. 66
172. 5	13	0 12	0 43	6 53	5. 88	4. 62	13	0 42	0 35	6 46	5. 60	4. 54	12	1 15	0 27	6 39	5. 57	4. 82
187. 5	13	0 12	0 44	6 51	5. 56	4. 76	14	0 43	0 38	6 48	5. 21	4. 85	14	1 16	0 33	6 43	5. 40	4. 78
202. 5	12	0 13	0 46	6 53	5. 51	4. 98	12	0 47	0 38	6 48	5. 32	4. 70	12	1 18	0 31	6 44	5. 04	5. 12
217. 5	15	0 14	0 48	6 56	5. 11	5. 08	13	0 47	0 42	6 50	5. 43	5. 27	12	1 14	0 37	6 43	5. 02	5. 25
232. 5	12	0 22	0 48	6 56	5. 38	5. 14	10	0 49	0 42	6 51	5. 26	5. 33	9	1 10	0 39	6 48	5. 29	4. 92
247. 5	11	0 18	0 43	6 50	5. 38	5. 07	10	0 41	0 49	6 52	5. 22	5. 60	12	1 12	0 41	6 49	4. 87	5. 57
262. 5	11	0 18	0 49	6 51	5. 20	5. 25	11	0 48	0 44	6 49	5. 03	5. 54	11	1 15	0 35	6 43	5. 20	5. 74
277. 5	10	0 13	0 42	6 52	4. 69	5. 25	10	0 40	0 41	6 44	4. 93	5. 35	11	1 16	0 32	6 41	5. 07	5. 67
292. 5	11	0 15	0 38	6 53	5. 03	5. 20	11	0 44	0 30	6 43	5. 03	5. 01	11	1 11	0 30	6 36	5. 21	4. 99
307. 5	11	0 17	0 45	6 44	5. 13	5. 33	11	0 45	0 36	6 38	5. 24	4. 55	11	1 16	0 28	6 37	4. 95	5. 09
322. 5	12	0 13	0 36	6 45	5. 66	4. 20	11	0 45	0 23	6 35	4. 95	4. 84	10	1 16	0 34	6 40	5. 16	4. 93
337. 5	14	0 10	0 36	6 46	5. 27	4. 39	13	0 46	0 34	6 43	5. 67	4. 60	9	1 19	0 30	6 39	5. 02	4. 94
352. 5	14	0 16	0 37	6 46	5. 85	4. 07	13	0 49	0 31	6 41	5. 39	4. 45	8	1 18	0 29	6 44	6. 13	4. 64
	277	0 15. 7	0 40. 4	6 50. 8	5. 64	4. 63	278	0 45. 2	0 35. 1	6 45. 9	5. 59	4. 69	263	1 14. 7	0 30. 6	6 42. 3	5. 46	4. 84

ϕ	$(\psi-\psi')=1h.\ 30m.$ . . . . $2h.\ 0m.$						$(\psi-\psi')=2h.\ 0m.$ . . . . $2h.\ 30m.$						$(\psi-\psi')=2h.\ 30m.$ . . . . $3h.\ 0m.$					
	Obs.	$(\psi-\psi')$	λ_3	λ_4	H_3	H_4	Obs.	$(\psi-\psi')$	λ_3	λ_4	H_3	H_4	Obs.	$(\psi-\psi')$	λ_3	λ_4	H_3	H_4
°		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*
7. 5	11	1 40	0 25	6 37	5. 37	4. 75	13	2 15	0 23	6 32	5. 33	5. 09	11	2 44	0 24	6 33	5. 34	5. 19
22. 5	15	1 44	0 27	6 39	5. 76	4. 89	14	2 17	0 23	6 37	5. 68	4. 88	9	2 48	0 22	6 30	5. 03	4. 82
37. 5	13	1 49	0 28	6 41	5. 77	4. 97	12	2 18	0 24	6 35	5. 42	4. 98	12	2 42	0 25	6 41	5. 48	5. 00
52. 5	11	1 44	0 24	6 43	5. 72	4. 49	13	2 8	0 21	6 38	5. 66	5. 06	15	2 45	0 24	6 38	5. 28	5. 35
67. 5	10	1 42	0 30	6 40	5. 89	4. 63	11	2 15	0 23	6 36	5. 46	5. 24	11	2 43	0 18	6 32	5. 52	5. 41
82. 5	14	1 45	0 26	6 38	5. 66	4. 71	12	2 15	0 19	6 34	5. 47	5. 00	10	2 45	0 18	6 32	5. 74	5. 48
97. 5	10	1 49	0 19	6 35	5. 88	4. 79	9	2 13	0 18	6 33	5. 56	4. 53	14	2 44	0 15	6 33	5. 55	5. 40
112. 5	11	1 44	0 22	6 36	5. 48	4. 94	9	2 16	0 21	6 33	5. 43	5. 10	9	2 46	0 13	6 30	5. 78	5. 09
127. 5	9	1 46	0 20	6 35	5. 76	4. 76	11	2 17	0 19	6 32	5. 71	4. 91	11	2 46	0 8	6 23	5. 41	5. 21
142. 5	13	1 44	0 20	6 31	5. 48	4. 39	11	2 15	0 16	6 31	5. 40	4. 79	12	2 43	0 15	6 30	5. 09	4. 85
157. 5	10	1 47	0 28	6 39	5. 23	4. 96	9	2 15	0 18	6 32	5. 22	4. 84	10	2 46	0 15	6 28	5. 17	4. 83
172. 5	11	1 45	0 28	6 38	5. 43	4. 67	13	2 13	0 29	6 40	4. 94	5. 02	11	2 41	0 22	6 33	4. 92	5. 25
187. 5	12	1 48	0 30	6 43	5. 25	4. 82	11	2 17	0 24	6 32	4. 93	4. 90	12	2 45	0 24	6 35	4. 81	5. 37
202. 5	11	1 45	0 33	6 40	4. 91	4. 76	13	2 12	0 29	6 38	4. 83	5. 03	13	2 41	0 27	6 37	4. 63	5. 41
217. 5	13	1 41	0 34	6 42	4. 77	5. 13	13	2 10	0 25	6 36	4. 77	5. 47	12	2 45	0 27	6 39	4. 37	5. 28
232. 5	13	1 47	0 35	6 41	5. 01	5. 60	13	2 18	0 29	6 37	4. 60	5. 38	12	2 44	0 26	6 37	4. 61	5. 91
247. 5	12	1 45	0 34	6 42	4. 88	5. 58	12	2 18	0 29	6 36	5. 03	6. 03	9	2 48	0 33	6 40	4. 83	5. 60
262. 5	10	1 43	0 33	6 40	5. 25	5. 62	12	2 11	0 30	6 37	4. 64	5. 35	12	2 43	0 25	6 36	4. 54	5. 85
277. 5	11	1 43	0 30	6 37	4. 93	5. 27	11	2 15	0 26	6 35	4. 70	6. 00	11	2 47	0 21	6 31	4. 98	5. 82
292. 5	9	1 40	0 34	6 39	5. 16	5. 45	11	2 14	0 23	6 33	4. 74	5. 39	10	2 43	0 23	6 30	4. 77	5. 58
307. 5	12	1 45	0 23	6 33	5. 16	5. 20	12	2 14	0 19	6 32	4. 51	5. 10	10	2 41	0 21	6 32	4. 76	5. 65
322. 5	11	1 46	0 23	6 35	4. 96	4. 78	10	2 14	0 16	6 28	4. 96	5. 43	10	2 47	0 18	6 29	5. 01	5. 19
337. 5	11	1 44	0 20	6 34	5. 43	4. 85	12	2 15	0 22	6 30	5. 06	5. 25	11	2 46	0 24	6 36	5. 08	5. 27
352. 5	11	1 41	0 25	6 33	5. 47	4. 57	12	2 15	0 20	6 30	5. 27	5. 09	11	2 46	0 24	6 36	5. 35	5. 09
	274	1 44. 4	0 27. 1	6 37. 9	5. 36	4. 94	279	2 14. 6	0 22. 8	6 34. 0	5. 14	5. 17	268	2 44. 6	0 21. 3	6 33. 4	5. 09	5. 33

TABLE II—*Containing average values belonging to the Arguments* $(\psi - \psi') = \frac{1}{2}\eta_1$ *and* $\phi = \frac{1}{2}\eta_3$—Continued.

LOWER TRANSITS.

ϕ	$(\psi-\psi')$ = 3h. 0m. . . . . 3h. 30m.						$(\psi-\psi')$ = 3h. 30m. . . . . 4h. 0m.						$(\psi-\psi')$ = 4h. 0m. . . . . 4h. 30m.					
	Obs.	$(\psi-\psi')$	λ_3	λ_4	H_3	H_4	Obs.	$(\psi-\psi')$	λ_3	λ_4	H'	H_4	Obs.	$(\psi-\psi')$	λ_3	λ_4	H_3	H_4
°		h. m.	h. m.	h. m.	Ft.	Ft.		h. m.	h. m.	h. m.	Ft.	Ft.		h. m.	h. m.	h. m.	Ft.	Ft.
7.5	11	3 17	0 19	6 32	5.30	5.40	12	3 43	0 20	6 32	4.74	5.49	12	4 17	0 28	6 42	4.84	5.84
22.5	14	3 9	0 25	6 36	5.41	5.42	13	3 44	0 22	6 37	4.98	5.60	12	4 16	0 25	6 40	4.71	5.37
37.5	12	3 13	0 16	6 33	5.14	5.38	12	3 45	0 19	6 38	4.96	5.56	12	4 15	0 28	6 43	4.90	5.54
52.5	14	3 15	0 18	6 24	5.23	5.45	12	3 47	0 25	6 33	5.03	5.47	12	4 15	0 24	6 43	4.82	5.66
67.5	12	3 11	0 18	6 35	5.30	5.09	14	3 45	0 20	6 40	5.02	5.54	15	4 11	0 22	6 39	5.04	5.80
82.5	12	3 15	0 12	6 28	5.37	5.20	13	3 46	0 15	6 29	5.09	5.52	13	4 15	4 20	6 34	4.91	5.66
97.5	11	3 16	0 16	6 30	5.07	5.45	9	3 46	0 10	6 29	5.24	5.69	13	4 12	0 14	6 30	5.07	5.82
112.5	11	3 13	0 14	6 31	5.24	5.04	11	3 41	0 13	6 30	5.02	5.60	13	4 17	0 12	6 31	4.87	5.67
127.5	11	3 15	0 13	6 27	4.92	5.37	12	3 47	0 15	6 32	5.00	5.42	13	4 16	0 13	6 28	4.60	5.62
142.5	10	3 14	0 15	6 26	5.09	5.38	10	3 45	0 14	6 28	4.93	5.45	10	4 14	0 12	6 30	4.80	5.81
157.5	11	3 14	0 17	6 28	4.55	5.40	11	3 44	0 21	6 34	4.92	5.40	13	4 14	0 13	6 30	4.72	5.78
172.5	12	3 14	0 22	6 33	4.85	5.37	11	3 45	0 22	6 33	4.56	5.54	10	4 18	0 25	6 40	4.52	5.37
187.5	13	3 15	0 28	6 37	4.79	5.49	11	3 50	0 26	6 38	4.39	5.72	10	4 16	0 30	6 39	4.11	5.63
202.5	13	3 17	0 25	6 35	4.37	5.62	12	3 44	0 27	6 38	4.28	5.97	11	4 15	0 30	6 44	4.38	6.00
217.5	12	3 14	0 24	6 36	4.79	5.50	13	3 44	0 25	6 39	4.06	5.77	15	4 15	0 31	6 41	4.03	6.07
232.5	13	3 16	0 27	6 38	4.52	5.72	13	3 45	0 29	6 39	4.34	6.25	13	4 18	0 33	6 43	3.93	5.92
247.5	14	3 13	0 25	6 37	4.43	5.89	13	3 50	0 28	6 38	4.16	6.23	11	4 15	0 30	6 39	4.03	6.08
262.5	13	3 15	0 21	6 31	4.79	6.13	12	3 45	0 28	6 38	4.30	6.06	12	4 10	0 22	6 35	4.16	6.32
277.5	11	3 13	0 23	6 33	4.63	6.00	12	3 44	0 22	6 35	4.08	5.86	12	4 15	0 24	6 34	4.67	6.06
292.5	13	3 15	0 22	6 32	4.55	6.20	13	3 48	0 19	6 24	4.84	5.89	10	4 13	0 21	6 33	4.34	6.28
307.5	11	3 16	0 16	6 27	4.43	5.72	10	3 49	0 15	6 32	4.91	6.11	11	4 15	0 17	6 30	4.47	5.69
322.5	11	3 18	0 15	6 28	4.60	5.65	9	3 48	0 16	6 30	4.73	6.03	9	4 14	0 24	6 34	4.51	5.90
337.5	11	3 16	0 18	6 31	4.99	5.84	12	3 47	0 14	6 30	4.76	5.67	9	4 16	0 20	6 34	4.88	5.75
352.5	9	3 13	0 16	6 25	5.01	5.50	11	3 42	0 25	6 37	5.37	5.75	12	4 14	0 24	6 36	4.62	5.75
	285	3 14.5	0 19.4	6 31.4	4.89	5.55	281	3 45.6	0 20.3	6 33.9	4.74	5.73	283	4 14.8	0 22.6	6 36.3	4.58	5.81

ϕ	$(\psi-\psi')$ = 4h. 30m. . . . . 5h. 0m.						$(\psi-\psi')$ = 5h. 0m. . . . . 5h. 30m.						$(\psi-\psi')$ = 5h. 30m. . . . . 6h. 0m.					
	Obs.	$(\psi-\psi')$	λ_3	λ_4	H_3	H_4	Obs.	$(\psi-\psi')$	λ_3	λ_4	H_3	H_4	Obs.	$(\psi-\psi')$	λ_3	λ_4	H_3	H_4
°		h. m.	h. m.	h. m.	Ft.	Ft.		h. m.	h. m.	h. m.	Ft.	Ft.		h. m.	h. m.	h. m.	Ft.	Ft.
7.5	11	4 44	0 27	6 44	4.83	5.75	10	5 12	0 35	6 48	4.78	5.69	10	5 44	0 39	6 53	4.78	5.86
22.5	7	4 48	0 33	6 48	5.00	5.90	11	5 17	0 39	6 50	4.85	5.85	11	5 46	0 45	7 1	4.82	5.79
37.5	13	4 43	0 32	6 52	4.64	6.02	11	5 13	0 34	6 52	4.93	5.70	12	5 44	0 44	7 5	4.79	6.07
52.5	13	4 44	0 33	6 52	4.81	5.73	13	5 14	0 36	6 52	4.49	5.78	10	5 46	0 42	7 1	5.06	5.71
67.5	13	4 45	0 25	6 53	4.61	6.22	12	5 15	0 34	6 56	4.91	5.62	13	5 46	0 42	7 1	4.64	5.76
82.5	12	4 44	0 22	6 40	4.77	5.98	12	5 14	0 30	6 51	4.87	5.75	9	5 46	0 35	6 54	4.64	6.22
97.5	12	4 49	0 21	6 38	4.87	5.93	12	5 16	0 16	6 37	4.91	6.10	10	5 44	0 32	6 51	4.76	5.98
112.5	11	4 50	0 17	6 32	4.42	6.25	11	5 15	0 18	6 39	4.72	5.73	11	5 44	0 26	6 43	4.82	6.29
127.5	10	4 48	0 20	6 35	4.90	5.68	11	5 13	0 18	6 39	4.56	5.77	11	5 45	0 28	6 46	4.44	6.03
142.5	11	4 44	0 22	6 37	4.46	5.80	12	5 14	0 20	6 35	4.72	5.89	12	5 47	0 32	6 49	4.58	5.88
157.5	11	4 46	0 19	6 36	4.84	5.53	10	5 16	0 27	6 49	4.60	6.07	12	5 49	0 32	6 46	4.49	5.89
172.5	12	4 47	0 32	6 42	4.23	5.47	10	5 16	0 33	6 48	4.36	6.00	11	5 44	0 34	6 48	4.15	5.61
187.5	10	4 46	0 32	6 42	4.19	5.79	11	5 13	0 41	6 51	3.90	5.85	12	5 42	0 41	6 56	4.07	5.74
202.5	11	4 44	0 32	7 44	3.84	5.89	9	5 17	0 48	6 57	4.06	5.95	10	5 49	0 49	7 0	3.96	6.00
217.5	11	4 49	0 40	6 55	3.89	6.33	11	5 17	0 44	6 59	4.20	6.27	9	5 44	0 50	6 50	3.90	5.76
232.5	12	4 47	0 40	6 50	3.76	6.50	11	5 9	0 40	6 52	3.99	6.10	13	5 41	0 56	7 4	3.61	6.49
247.5	11	4 45	0 37	6 45	4.05	6.18	15	5 12	0 45	6 55	3.61	6.37	14	5 47	0 48	7 3	3.76	6.32
262.5	12	4 51	0 31	6 45	4.30	6.65	13	5 12	0 36	6 46	4.05	6.42	13	5 43	0 49	6 58	3.97	6.13
277.5	12	4 45	0 30	6 43	4.10	6.30	11	5 18	0 28	6 40	4.18	6.25	11	5 48	0 46	6 53	3.56	6.46
292.5	13	4 43	0 22	6 34	4.05	6.25	13	5 14	0 28	6 43	4.30	6.21	11	5 43	0 33	6 50	4.35	6.28
307.5	12	4 44	0 20	6 36	4.53	6.00	10	5 12	0 28	6 43	4.30	6.43	11	5 44	0 34	6 50	4.12	6.21
322.5	10	4 42	0 20	6 34	4.69	5.92	11	5 13	0 25	6 39	4.40	5.90	13	5 45	0 32	6 47	4.42	5.97
337.5	12	4 46	0 27	6 42	4.59	5.98	12	5 17	0 33	6 46	5.05	6.00	11	5 45	0 31	6 48	4.62	5.87
352.5	10	4 44	0 27	6 43	5.08	5.60	11	5 15	0 32	6 48	4.67	5.94	11	5 43	0 38	6 53	5.00	5.75
	272	4 45.8	0 27.6	6 42.2	4.48	5.99	273	5 14.3	0 32.0	6 49.2	4.48	5.99	271	5 45.0	0 39.1	6 53.8	4.39	6.00

TABLE II—*Containing average values belonging to the Arguments* $(\psi-\psi')=\frac{1}{2}\eta_1$ *and* $\phi=\eta_3$—Continued.

LOWER TRANSITS.

ϕ	$(\psi-\psi')=6h.\ 0m.$ . . . . $6h.\ 30m.$ Obs.	$(\psi-\psi')$	λ_2	λ_4	H_4	H_4
°		h. m.	h. m.	h. m.	Ft.	Ft.
7.5	13	6 13	0 46	7 2	5.07	5.69
22.5	11	6 16	0 48	7 4	4.91	5.85
37.5	10	6 17	0 52	7 10	4.86	5.53
52.5	10	6 13	0 44	7 9	5.12	5.92
67.5	14	6 10	0 45	7 7	4.72	5.80
82.5	14	6 11	0 42	7 1	4.66	5.86
97.5	16	6 12	0 39	7 0	4.82	5.83
112.5	12	6 12	0 29	6 52	4.89	5.97
127.5	13	6 15	0 34	6 54	4.64	5.80
142.5	11	6 15	0 27	6 43	4.35	5.99
157.5	9	6 18	0 46	6 56	4.75	6.90
172.5	11	6 14	0 42	6 56	4.34	5.75
187.5	13	6 15	0 47	6 58	4.41	5.96
202.5	10	6 18	0 51	7 6	4.05	5.69
217.5	12	6 12	1 2	7 11	4.14	6.42
232.5	12	6 12	0 54	7 5	3.80	6.08
247.5	11	6 18	1 2	7 12	3.93	6.40
262.5	14	6 8	0 52	7 1	3.69	6.30
277.5	15	6 13	0 46	6 58	4.16	6.39
292.5	12	6 15	0 46	7 0	4.14	6.16
307.5	14	6 12	0 40	6 52	4.18	6.24
322.5	11	6 15	0 36	6 53	4.34	5.87
337.5	11	6 13	0 38	6 55	4.57	5.91
352.5	12	6 19	0 43	7 0	4.74	5.60
	291	6 14.0	0 44.6	7 0.2	4.47	5.96

ϕ	$(\psi-\psi')=6h.\ 30m.$ . . . . $7h.\ 0m.$ Obs.	$(\psi-\psi')$	λ_2	λ_4	H_2	H_4
°		h. m.	h. m.	h. m.	Ft.	Ft.
7.5	12	6 45	0 52	7 8	4.99	5.81
22.5	12	6 44	0 47	7 6	5.19	5.48
37.5	11	6 47	0 50	7 12	5.10	5.47
52.5	12	6 42	0 57	7 14	4.90	5.73
67.5	13	6 48	0 57	7 20	4.70	5.90
82.5	16	6 45	0 55	7 15	4.75	5.46
97.5	14	6 49	0 47	7 7	4.94	5.86
112.5	12	6 43	0 46	7 3	4.54	6.26
127.5	13	6 49	0 43	6 59	4.66	6.09
142.5	11	6 44	0 40	7 0	4.68	5.54
157.5	12	6 44	0 45	7 1	4.61	5.79
172.5	11	6 43	0 51	7 4	4.61	5.78
187.5	11	6 41	0 52	6 56	4.26	5.77
202.5	11	6 49	1 0	7 10	4.17	5.93
217.5	12	6 42	0 59	7 14	4.00	5.81
232.5	11	6 47	1 13	7 19	4.03	6.05
247.5	11	6 45	1 5	1 13	4.04	6.09
262.5	13	6 45	1 4	7 12	3.73	6.05
277.5	14	6 48	0 58	7 7	3.78	6.18
292.5	13	6 46	0 53	7 7	3.96	6.10
307.5	13	6 48	0 50	7 5	4.25	6.23
322.5	10	6 49	0 50	7 4	4.50	5.86
337.5	10	6 46	0 42	6 56	4.79	5.72
352.5	11	6 47	0 47	6 56	5.10	5.52
	289	6 46.0	0 52.6	7 7.0	4.51	5.85

ϕ	$(\psi-\psi')=7h.\ 0m.$ . . . . $7h.\ 30m.$ Obs.	$(\psi-\psi')$	λ_2	λ_4	H_2	H_4
°		h. m.	h. m.	h. m.	Ft.	Ft.
7.5	10	7 14	0 51	7 12	5.19	5.13
22.5	10	7 17	0 52	7 15	5.35	5.15
37.5	10	7 16	0 56	7 18	5.15	5.17
52.5	12	7 15	0 0	7 21	5.17	5.36
67.5	10	7 17	0 52	7 12	5.30	5.62
82.5	11	7 15	0 58	7 19	5.01	4.96
97.5	14	7 16	0 54	7 14	5.00	5.68
112.5	11	7 8	0 47	7 5	4.77	5.52
127.5	14	7 16	0 47	7 5	4.90	5.55
142.5	12	7 12	0 47	7 5	4.54	5.78
157.5	12	7 16	0 48	7 3	4.51	5.64
172.5	12	7 17	0 56	7 7	4.49	5.90
187.5	12	7 17	1 1	7 12	4.26	5.62
202.5	12	7 18	1 1	7 12	4.53	5.44
217.5	12	7 16	1 10	7 20	4.13	5.99
232.5	10	7 14	1 2	7 14	3.85	5.22
247.5	12	7 11	1 9	7 18	3.80	5.64
262.5	11	7 14	1 12	7 19	4.05	5.64
277.5	12	7 16	1 4	7 19	4.06	5.86
292.5	15	7 16	0 59	7 10	4.25	5.91
307.5	12	7 15	0 56	7 7	4.28	5.74
322.5	10	7 12	0 47	6 59	4.75	5.59
337.5	12	7 13	0 52	7 6	4.83	5.62
352.5	10	7 16	0 52	7 15	5.08	5.51
	278	7 14.8	0 56.4	7 11.6	4.64	5.55

ϕ	$(\psi-\psi')=7h.\ 30m.$ . . . . $8h.\ 0m.$ Obs.	$(\psi-\psi')$	λ_2	λ_4	H_2	H_4
°		h. m.	h. m.	h. m.	Ft.	Ft.
7.5	10	7 41	0 57	7 13	5.37	5.36
22.5	11	7 47	1 4	7 21	5.31	5.35
37.5	10	7 45	1 1	7 24	5.69	5.16
52.5	9	7 43	1 2	7 27	4.93	5.40
67.5	9	7 44	1 2	7 25	5.57	5.33
82.5	11	7 42	1 5	7 30	5.18	5.57
97.5	13	7 47	1 0	7 19	5.02	4.93
112.5	13	7 44	0 55	7 15	4.79	5.45
127.5	12	7 49	0 54	7 9	4.83	5.90
142.5	12	7 46	0 52	7 10	4.94	5.50
157.5	12	7 45	0 59	7 11	4.87	5.63
172.5	11	7 47	0 58	7 9	4.95	5.28
187.5	11	7 44	1 0	7 13	4.73	5.53
202.5	9	7 47	1 13	7 21	4.45	5.50
217.5	11	7 43	1 12	7 21	4.46	5.74
232.5	11	7 46	1 17	7 24	4.17	5.72
247.5	12	7 44	1 16	7 22	4.24	6.00
262.5	11	7 48	1 9	7 22	4.35	5.67
277.5	11	7 47	1 11	7 20	3.67	5.74
292.5	13	7 46	1 5	7 12	4.48	5.84
307.5	11	7 45	1 3	7 13	4.63	5.49
322.5	15	7 45	0 57	7 11	4.88	5.77
337.5	13	7 43	0 51	7 5	5.10	5.36
352.5	12	7 46	0 57	7 12	4.97	5.21
	273	7 45.2	1 2.5	7 17.0	4.81	5.52

ϕ	$(\psi-\psi')=8h.\ 0m.$ . . . . $8h.\ 30m.$ Obs.	$(\psi-\psi')$	λ_2	λ_4	H_2	H_4
°		h. m.	h. m.	h. m.	Ft.	Ft.
7.5	11	8 17	1 2	7 19	5.26	5.08
22.5	11	8 17	1 3	7 19	5.64	4.88
37.5	12	8 14	1 6	7 22	5.69	5.37
52.5	12	8 17	1 2	7 24	5.71	4.47
67.5	11	8 13	1 1	7 22	5.57	4.93
82.5	11	8 14	1 3	7 24	5.32	5.26
97.5	13	8 14	1 2	7 21	5.16	5.21
112.5	15	8 12	0 57	7 13	5.27	4.97
127.5	13	8 17	0 56	7 12	5.14	4.97
142.5	13	8 15	0 57	7 11	5.21	5.41
157.5	11	8 12	0 58	7 12	4.61	5.66
172.5	12	8 15	1 7	7 12	5.00	5.61
187.5	11	8 13	1 9	7 16	4.78	5.62
202.5	12	8 12	1 9	7 18	4.55	5.60
217.5	11	8 18	1 12	7 20	4.49	5.40
232.5	11	8 14	1 17	7 23	4.36	5.79
247.5	10	8 16	1 10	7 16	4.31	5.48
262.5	12	8 13	1 14	7 21	4.09	5.40
277.5	11	8 15	1 9	7 19	4.14	5.52
292.5	13	8 13	1 7	7 19	4.58	5.57
307.5	13	8 9	1 9	7 16	4.65	5.53
322.5	14	8 15	1 0	7 13	4.86	5.42
337.5	13	8 17	0 57	7 13	5.00	5.24
352.5	11	8 17	1 1	7 15	5.37	5.00
	287	8 14.6	1 4.6	7 17.5	4.95	5.31

ϕ	$(\psi-\psi')=8h.\ 30m.$ . . . . $9h.\ 0m.$ Obs.	$(\psi-\psi')$	λ_2	λ_4	H_2	H_4
°		h. m.	h. m.	h. m.	Ft.	Ft.
7.5	10	8 44	0 56	7 12	5.82	4.53
22.5	11	8 45	1 6	7 18	5.31	4.83
37.5	9	8 48	1 4	7 21	6.25	4.46
52.5	12	8 46	1 7	7 30	5.46	5.23
67.5	9	8 45	1 2	7 21	5.23	5.05
82.5	11	8 44	1 9	7 25	5.65	5.10
97.5	10	8 44	1 3	7 19	5.18	4.80
112.5	12	8 49	1 1	7 20	5.17	4.80
127.5	13	8 48	0 58	7 18	5.15	5.01
142.5	12	8 44	1 2	7 17	5.07	5.43
157.5	13	8 48	0 56	7 8	5.13	5.18
172.5	13	8 43	1 3	7 15	5.08	5.28
187.5	13	8 46	1 12	7 18	4.82	5.34
202.5	12	8 44	1 11	7 16	4.73	5.32
217.5	12	8 49	1 17	7 24	4.62	5.44
232.5	11	8 46	1 16	7 24	4.26	5.52
247.5	12	8 46	1 12	7 21	4.51	5.46
262.5	10	8 44	1 13	7 22	4.64	5.51
277.5	13	8 49	1 15	7 19	4.14	5.40
292.5	13	8 43	1 5	7 13	4.44	5.29
307.5	13	8 46	1 6	7 14	4.99	5.20
322.5	11	8 48	1 1	7 13	4.79	4.87
337.5	10	8 46	0 55	7 12	5.37	4.64
352.5	10	8 46	0 56	7 15	5.59	4.81
	275	8 45.9	1 5.4	7 18.2	5.06	5.10

TABLE II.—*Containing average values belonging to the Arguments* $(\psi-\psi')=\frac{1}{2}\,\eta_1$ *and* $\phi=\frac{1}{2}\,\eta_3$—Continued.

LOWER TRANSITS.

ϕ	$(\psi-\psi')$ = 9*h*. 0*m*. . . . . 9*h*. 30*m*.						$(\psi-\psi')$ = 9*h*. 30*m*. . . . . 10*h*. 0*m*.						$(\psi-\psi')$ = 10*h*. 0*m*. . . . . 10*h*. 30*m*.					
	Obs.	$(\psi-\psi')$	λ_3	λ_4	H_3	H_4	Obs.	$(\psi-\psi')$	λ_3	λ_4	H_3	H_4	Obs.	$(\psi-\psi')$	λ_3	λ_4	H_3	H_4
°		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*
7.5	13	9 13	1 4	7 20	5.85	4.74	13	9 48	0 57	7 13	5.80	4.53	12	10 20	0 56	7 7	5.92	4.30
22.5	10	9 15	1 0	7 19	5.75	4.28	12	9 49	1 2	7 16	5.67	4.88	12	10 16	0 54	7 8	6.28	3.91
37.5	11	9 15	1 1	7 20	5.63	4.77	10	9 46	0 59	7 14	5.90	4.30	9	10 13	1 2	7 19	5.93	4.42
52.5	11	9 16	1 7	7 25	5.80	4.71	8	9 49	1 3	7 17	5.80	4.57	9	10 14	0 58	7 18	6.53	4.06
67.5	14	9 14	1 3	7 23	5.82	4.73	11	9 44	1 0	7 18	6.03	4.46	10	10 14	0 57	7 18	6.07	4.83
82.5	11	9 13	0 51	7 13	5.87	4.12	11	9 49	0 56	7 18	6.06	4.79	10	10 16	0 53	7 13	6.10	4.10
97.5	10	9 16	0 58	7 15	5.35	4.85	9	9 44	0 58	7 17	5.94	4.87	10	10 12	0 52	7 15	6.00	4.20
112.5	11	9 17	0 55	7 15	5.97	4.53	9	9 44	0 59	7 12	5.86	4.41	11	10 13	0 44	7 6	5.80	4.49
127.5	12	9 14	0 56	7 12	5.89	4.58	13	9 44	0 58	7 13	5.36	4.71	15	10 17	0 51	7 7	5.95	4.27
142.5	14	9 13	0 57	7 11	5.26	4.68	12	9 47	0 58	7 11	5.58	4.80	10	10 12	0 51	7 6	5.97	4.52
157.5	12	9 17	1 3	7 13	5.33	5.23	12	9 47	1 1	7 11	5.42	4.86	11	10 10	0 52	7 6	5.63	4.57
172.5	12	9 17	1 7	7 16	5.14	5.51	12	9 46	0 58	7 9	5.47	4.76	13	10 14	0 57	7 6	5.66	4.96
187.5	11	9 19	1 7	7 17	5.44	5.15	10	9 42	1 7	7 16	5.38	5.07	11	10 13	1 2	7 10	5.48	4.97
202.5	10	9 21	1 10	7 19	5.04	5.01	11	9 42	1 10	7 16	5.13	5.17	13	10 14	1 9	7 14	5.23	5.31
217.5	9	9 17	1 14	7 20	5.03	5.21	11	9 48	1 9	7 15	5.15	5.38	12	10 16	1 5	7 12	5.36	5.11
252.5	10	9 18	1 14	7 21	4.87	5.10	10	9 43	1 6	7 13	4.74	5.18	11	10 13	1 9	7 14	5.10	5.38
247.5	9	9 16	1 14	7 21	4.69	5.25	10	9 46	1 18	7 20	4.75	5.58	12	10 17	1 3	7 9	4.98	5.16
262.5	12	9 18	1 11	7 17	4.46	5.41	11	9 45	1 9	7 13	4.85	5.12	10	10 14	1 10	7 15	5.03	5.29
277.5	11	9 15	1 7	7 13	4.87	4.93	10	9 49	1 8	7 11	4.64	5.19	11	10 19	0 56	7 3	4.74	5.18
292.5	12	9 14	1 7	7 16	4.55	5.09	11	9 44	1 7	7 13	4.39	4.95	10	10 14	1 0	7 6	5.14	4.64
307.5	12	9 17	1 3	7 13	5.22	5.10	12	9 45	0 58	7 9	5.18	4.87	14	10 15	0 54	7 3	5.08	4.78
322.5	9	9 15	0 58	7 10	5.40	4.73	13	9 44	1 4	7 12	5.33	4.87	13	10 13	0 54	7 5	5.46	4.48
337.5	13	9 13	1 0	7 13	5.45	4.91	14	9 41	0 57	7 11	6.25	4.80	13	10 15	0 57	7 8	5.47	4.68
351.5	13	9 9	1 0	7 14	5.63	4.92	13	9 43	0 59	7 13	5.51	4.89	13	10 18	0 53	7 5	5.77	4.39
	272	9 15.5	1 3.6	7 16.5	5.34	4.90	268	9 55.4	1 2.6	7 13.8	5.42	4.88	276	10 14.7	0 57.4	7 9.7	5.61	4.67

ϕ	$(\psi-\psi')$ = 10*h*. 30*m*. . . . . 11*h*. 0*m*.						$(\psi-\psi')$ = 11*h*. 0*m*. . . . . 11*h*. 30*m*.						$(\psi-\psi')$ = 11*h*. 30*m*. . . . . 12*h*. 0*m*.					
	Obs.	$(\psi-\psi')$	λ_3	λ_4	H_3	H_4	Obs.	$(\psi-\psi')$	λ_3	λ_4	H_3	H_4	Obs.	$(\psi-\psi')$	λ_3	λ_4	H_3	H_4
°		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*
7.5	9	10 45	0 49	7 4	6.13	4.42	12	11 11	0 51	7 3	6.04	4.49	13	11 44	0 42	6 55	6.01	4.04
22.5	11	10 42	0 52	7 4	6.26	4.06	12	11 11	0 52	7 4	6.08	4.25	13	11 50	0 42	6 57	6.18	4.70
37.5	13	10 51	0 55	7 9	5.94	4.15	16	11 15	0 49	7 5	6.09	4.32	14	11 50	0 45	6 59	6.22	4.33
52.5	10	10 44	0 50	7 10	5.94	3.98	9	11 20	0 49	7 3	5.93	4.24	9	11 48	0 41	6 57	6.04	4.01
67.5	8	10 46	0 53	7 13	6.17	4.51	11	11 14	0 50	7 6	6.04	4.45	11	11 42	0 44	7 3	6.26	3.96
82.5	11	10 46	0 54	7 12	6.18	4.32	10	11 16	0 46	7 0	6.15	4.24	9	11 48	0 49	7 3	6.09	4.31
97.5	12	10 45	0 45	7 3	5.84	4.60	12	11 18	0 46	6 57	6.06	4.18	12	11 45	0 38	6 55	6.31	4.25
112.5	10	10 46	0 48	7 6	6.02	4.51	10	11 15	0 40	6 56	5.95	4.26	9	11 42	0 32	6 51	6.14	4.12
127.5	9	10 47	0 45	7 3	5.85	4.09	10	11 10	0 44	6 58	6.23	4.05	12	11 43	0 38	6 54	5.92	4.32
142.5	11	10 40	0 50	7 3	5.75	4.51	13	11 12	0 43	6 57	5.95	4.19	14	11 46	0 40	6 52	5.79	4.30
157.5	15	10 45	0 51	7 1	5.99	4.59	13	11 16	0 42	6 57	5.87	4.41	12	11 49	0 42	6 56	5.66	4.40
172.5	12	10 44	0 59	7 3	5.21	4.65	13	11 18	0 52	6 59	5.60	4.73	11	11 45	0 45	6 52	5.84	4.37
187.5	14	10 45	0 59	7 7	5.35	4.74	13	11 16	0 54	7 1	5.48	4.76	13	11 44	0 47	6 54	5.47	4.31
202.5	11	10 46	1 2	7 7	5.29	5.19	11	11 19	0 58	7 4	5.48	5.25	9	11 44	0 51	6 59	5.67	4.55
217.5	12	10 50	1 5	7 10	5.08	5.17	11	11 14	0 58	7 4	5.28	5.40	12	11 41	0 53	7 1	5.31	4.76
232.5	10	10 43	1 0	7 8	5.31	5.14	12	11 12	1 1	7 5	5.28	5.10	13	11 43	0 54	7 0	4.99	5.40
247.5	9	10 47	1 0	7 8	4.80	5.09	11	11 16	0 56	7 1	5.33	5.31	11	11 47	0 52	6 59	5.18	5.38
262.5	11	10 46	0 58	7 4	5.26	5.02	12	11 15	0 56	7 1	4.89	4.80	9	11 48	0 48	6 54	5.02	5.12
277.5	10	10 48	0 58	7 3	4.92	5.57	11	11 16	0 51	6 59	4.96	5.22	12	11 45	0 46	6 51	5.15	4.68
292.5	9	10 44	0 54	6 58	4.98	5.00	11	11 18	0 44	6 53	5.10	4.81	9	11 46	0 43	6 46	4.88	5.15
307.5	11	10 43	0 50	6 59	4.99	4.73	10	11 14	0 50	6 56	5.56	4.41	8	11 48	0 45	6 45	5.30	4.68
322.5	13	10 45	0 52	6 57	5.48	4.71	13	11 18	0 46	6 53	5.21	4.33	10	11 47	0 39	6 50	5.46	4.49
337.5	12	10 47	0 52	7 1	5.49	4.28	13	11 18	0 46	6 56	5.73	4.08	12	11 39	0 41	6 51	5.85	4.31
352.5	11	10 49	0 50	7 2	5.91	4.33	11	11 15	0 50	6 58	6.00	3.88	12	11 42	0 43	6 53	5.49	4.14
	264	10 45.5	0 53.8	7 4.8	5.59	4.64	280	11 15.1	0 47.2	6 59.8	5.68	4.55	269	11 45.8	0 44.2	6 54.8	5.68	4.50

TABLE III—*Containing average values belonging to the Arguments* $(\psi - \psi') = \frac{1}{2}\eta_1$ and η_2

COMBINED TRANSITS.

$\eta_2 = 15°$

$(\psi-\psi')$	Obs.	λ'_1	λ'_2	H'_1	H'_2
h. m.		h. m.	h. m.	Ft.	Ft.
0 15	21	0 40	6 51	6.51	3.52
0 45	23	0 32	6 46	6.33	3.49
1 15	23	0 30	6 42	6.32	3.73
1 45	22	0 27	6 38	6.15	4.09
2 15	21	0 24	6 37	6.15	4.15
2 45	23	0 20	6 34	5.59	4.46
3 15	24	0 20	6 35	5.62	4.88
3 45	24	0 19	6 35	5.43	5.03
4 15	23	0 23	6 40	5.38	5.07
4 45	25	0 24	6 40	5.15	5.34
5 15	25	0 28	6 43	4.99	5.33
5 45	26	0 35	6 51	5.15	5.51
6 15	26	0 38	6 58	5.31	5.58
6 45	24	0 45	6 58	5.24	5.08
7 15	26	0 49	7 7	5.37	4.77
7 45	22	0 53	7 11	5.78	5.03
8 15	24	0 56	7 11	5.84	4.73
8 45	23	0 57	7 10	6.13	4.18
9 15	23	0 56	7 8	6.21	4.12
9 45	22	0 54	7 6	6.64	3.88
10 15	24	0 52	7 4	6.46	3.87
10 45	25	0 47	7 0	6.59	3.46
11 15	21	0 44	6 56	6.61	3.47
11 45	21	0 37	6 50	6.57	3.48
	561	0 37.9	6 52.3	5 89.4	4 42.6

$\eta_2 = 30°$

$(\psi-\psi')$	Obs.	λ'_1	λ'_2	H'_1	H'_2
h. m.		h. m.	h. m.	Ft.	Ft.
0 15	21	0 34	6 45	6.38	3.57
0 45	22	0 35	6 46	6.54	3.45
1 15	21	0 33	6 46	6.22	3.56
1 45	22	0 31	6 44	6.10	3.83
2 15	23	0 23	6 37	5.93	4.30
2 45	23	0 21	6 34	5.85	4.45
3 15	22	0 23	6 38	5.64	4.56
3 45	23	0 21	6 37	5.45	4.89
4 15	25	0 21	6 35	5.39	5.25
4 45	23	0 29	6 44	5.21	5.23
5 15	24	0 28	6 47	5.35	5.23
5 45	22	0 36	6 53	5.04	5.33
6 15	25	0 41	6 56	5.15	5.16
6 45	23	0 44	7 1	4.99	5.11
7 15	25	0 49	7 7	5.27	4.97
7 45	22	0 55	7 10	5.44	4.64
8 15	24	0 57	7 12	5.70	4.30
8 45	23	0 58	7 14	6.08	4.41
9 15	22	0 58	7 11	6.22	4.18
9 45	23	0 54	7 9	6.51	3.87
10 15	22	0 52	7 5	6.45	3.79
10 45	21	0 47	7 1	6.79	3.82
11 15	23	0 45	6 59	6.70	3.39
11 45	22	0 42	6 56	6.78	3.32
	546	0 39.0	6 53.6	5.882	4.37[illegible]

$\eta_2 = 45°$

$(\psi-\psi')$	Obs.	λ'_1	λ_2'	H'_1	H'_2
h. m.		h. m.	h. m.	Ft.	Ft.
0 15	20	0 37	6 49	6.67	3.65
0 45	20	0 35	6 47	6.50	3.59
1 15	23	0 29	6 42	6.27	3.76
1 45	23	0 28	6 42	6.04	3.87
2 15	26	0 27	6 41	6.01	4.18
2 45	20	0 24	6 37	5.69	4.50
3 15	24	0 20	6 36	5.67	4.67
3 45	23	0 22	6 38	5.49	4.96
4 15	25	0 25	6 43	5.32	4.95
4 45	23	0 27	6 43	5.03	5.22
5 15	24	0 33	6 51	5.19	5.39
5 45	23	0 39	6 55	5.17	5.36
6 15	25	0 40	6 57	5.14	5.38
6 45	23	0 46	7 5	5 28	5.24
7 15	26	0 52	7 14	5.16	4.84
7 45	24	0 57	7 11	5.12	4.83
8 15	23	0 56	7 11	5.62	4.30
8 45	26	0 59	7 11	5.78	4.44
9 15	22	0 57	7 12	6.14	4.11
9 45	22	0 58	7 11	6.33	4.08
10 15	22	0 54	7 6	6.40	3.90
10 45	24	0 50	7 3	6.85	3.78
11 15	23	0 46	6 57	6.74	3.58
11 45	21	0 41	6 54	6.80	3.56
	555	0 40.1	6 54.8	5.850	4.427

$\eta_2 = 60°$

$(\psi-\psi')$	Obs.	λ'_1	λ'_2	H'_2	H'_2
h. m.		h. m.	h. m.	Ft.	Ft.
0 15	23	0 39	6 52	6.43	3.79
0 45	20	0 33	6 45	6.43	3.77
1 15	22	0 32	6 46	6.28	3.93
1 45	20	0 27	6 41	6.15	4.20
2 15	21	0 26	6 38	5.79	4.31
2 45	22	0 25	6 38	5.70	4.56
3 15	24	0 21	6 36	5.52	4.74
3 45	23	0 23	6 36	5.32	5.01
4 15	24	0 26	6 42	5.22	5.11
4 45	24	0 29	6 46	5.03	5.31
5 15	24	0 33	6 52	5.06	5.47
5 45	24	0 40	6 57	4.97	5.37
6 15	27	0 43	7 1	5.06	5.40
6 45	28	0 49	7 6	5.13	5.23
7 15	25	0 53	7 14	5.07	4.99
7 45	25	0 58	7 13	5.29	4.95
8 15	22	0 58	7 14	5.40	4.80
8 45	23	0 58	7 10	5.60	4.58
9 15	22	0 59	7 14	6.00	4.07
9 45	21	0 58	7 9	6.07	4.22
10 15	22	0 52	7 7	6.53	3.98
10 45	19	0 52	7 7	6.47	3.84
11 15	22	0 42	7 2	6.62	3.89
11 45	25	0 43	6 57	6.37	3.76
	552	0 40.8	6 56.0	5.771	4.554

$\eta_2 = 75$

$(\psi-\psi')$	Obs.	λ'_1	λ'_2	H'_1	H'_2
h. m.		h. m.	h. m.	Ft.	Ft.
0 15	21	0 42	6 52	6.31	4.13
0 45	23	0 35	6 48	6.23	4.01
1 15	22	0 31	6 43	6.18	4.14
1 45	24	0 28	6 41	5.90	4.28
2 15	22	0 25	6 38	5.80	4.42
2 45	25	0 21	6 36	5.58	4.72
3 15	20	0 22	6 36	5.37	5.04
3 45	23	0 22	6 40	5.33	4.99
4 15	22	0 26	6 40	5.09	5.35
4 45	25	0 29	6 44	4.83	5.32
5 15	22	0 35	6 51	4.67	5.52
5 45	24	0 41	7 0	4.93	5.50
6 15	22	0 48	7 3	4.80	5.48
6 45	24	0 42	7 9	5.03	5.22
7 15	26	0 57	7 14	4.95	5.12
7 45	25	0 57	7 12	5.21	4.99
8 15	24	1 1	7 18	5.46	4.84
8 45	26	1 2	7 16	5.40	4.97
9 15	24	1 0	7 12	5.79	4.53
9 45	23	0 56	7 10	5.73	4.18
10 15	21	0 55	7 8	6.23	3.91
10 45	21	0 50	7 2	6.14	3.94
11 15	21	0 47	6 58	6.30	4.03
11 45	21	0 45	6 57	6.33	3.99
	551	0 42.0	6 56.2	5 56.6	4 69.2

$\eta_2 = 90°$

$(\psi-\psi')$	Obs.	λ'_1	λ'_2	H'_1	H'_2
h. m.		h. m.	h. m.	Ft.	Ft.
0 15	23	0 38	6 50	6.05	4.10
0 45	21	0 38	6 44	5.92	4.49
1 15	20	0 32	6 46	5.88	4.42
1 45	22	0 28	6 39	5.76	4.45
2 15	22	0 26	6 40	5.66	4.85
2 45	22	0 24	6 34	5.50	4.83
3 15	23	0 25	6 37	5.25	5.01
3 45	22	0 24	6 42	5.09	5.39
4 15	20	0 28	6 41	5.00	5.45
4 45	23	0 32	6 48	4.88	5.77
5 15	27	0 34	6 50	4.75	5.68
5 45	23	0 44	6 59	4.83	5.67
6 15	23	0 48	7 5	4.71	6.00
6 45	25	0 53	7 8	4.73	5.54
7 15	24	0 58	7 15	4.75	5.38
7 45	22	1 2	7 20	5.13	5.17
8 15	24	1 4	7 21	5.04	4.90
8 45	22	1 6	7 18	5.30	4.90
9 15	24	1 5	7 17	5.43	4.84
9 45	23	1 0	7 12	5.77	4.67
10 15	25	0 54	7 8	5.80	4.38
10 45	23	0 51	7 3	5.86	3.99
11 15	22	0 47	6 57	6.01	4.11
11 45	23	0 41	6 54	5.90	4.03
	548	0 43.4	6 57.0	5.376	4.917

$\eta_2 = 105°$

$(\psi-\psi')$	Obs.	λ'_1	λ'_2	H'_1	H'_2
h. m.		h. m.	h. m.	Ft.	Ft.
0 15	21	0 37	6 48	5.74	4.21
0 45	20	0 33	6 45	5.43	4.30
1 15	23	0 30	6 42	5.64	4.59
1 45	22	0 26	6 36	5.44	4.89
2 15	24	0 28	6 39	5.40	4.99
2 45	22	0 23	6 36	5.48	5.25
3 15	23	0 22	6 38	5.31	5.26
3 45	23	0 24	6 37	4.98	5.51
4 15	24	0 28	6 44	4.79	5.31
4 45	22	0 33	6 48	4.69	5.84
5 15	25	0 26	6 51	4.71	5.83
5 45	21	0 42	6 58	4.45	5.96
6 15	26	0 48	7 4	4.67	5.96
6 45	22	0 57	7 12	4.81	5.84
7 15	26	0 58	7 14	4.64	5.52
7 45	25	1 4	7 19	4.68	5.54
8 15	25	1 7	7 21	4.93	5.17
8 45	26	1 5	7 18	4.98	5.04
9 15	23	1 7	7 19	5.16	4.92
9 45	22	1 3	7 15	5.48	4.62
10 15	24	0 58	7 6	5.58	4.68
10 45	22	0 52	7 4	5.66	4.53
11 15	25	0 51	7 2	5.83	4.56
11 45	23	0 44	6 54	5.90	4.36
	559	0 44.0	6 57.1	5.182	5.112

$\eta_2 = 120°$

$(\psi-\psi')$	Obs.	λ'_2	λ'_2	H'_1	H'_2
h. m.		h. m.	h. m.	Ft.	Ft.
0 15	22	0 40	6 52	5.53	4.82
0 45	23	0 33	6 44	5.55	4.64
1 15	18	0 32	6 43	5.25	4.59
1 45	22	0 28	6 41	5.33	5.06
2 15	24	0 27	6 39	5.34	5.35
2 45	17	0 24	6 35	5.16	5.42
3 15	22	0 21	6 34	5.09	5.69
3 45	24	0 23	6 37	4.97	5.84
4 15	23	0 27	6 40	4.74	5.93
4 45	21	0 32	6 44	4.56	6.04
5 15	24	0 36	6 52	4.47	5.97
5 45	22	0 46	7 2	4.49	6.11
6 15	24	0 52	7 6	4.41	6.15
6 45	23	0 55	7 13	4.63	5.99
7 15	25	1 6	7 19	4.62	5.88
7 45	24	1 5	7 21	4.83	5.65
8 15	22	1 9	7 22	4.61	5.33
8 45	25	1 10	7 22	4.87	5.23
9 15	23	1 7	7 18	4.95	5.21
9 45	24	1 3	7 18	5.21	4.92
10 15	22	1 1	7 13	5.04	4.88
10 45	24	0 56	7 7	5.59	4.90
11 15	24	0 51	7 2	5.44	4.65
11 45	23	0 46	6 58	5.69	4.69
	565	0 45.4	6 58.4	5.015	5.372

TABLE III—*Containing average values belonging to the Arguments* $(\psi-\psi')=\eta_1$ *and* η_2—Continued.

COMBINED TRANSITS.

$(\psi-\psi')$	$\eta_2=135°$					$\eta_2=150°$					$\eta_2=165°$					$\eta_2=180°$				
	Obs.	λ'_1	λ'_2	H'_1	H'_2	Obs.	λ'_1	λ'_2	H'_1	H'_2	Obs.	λ'_1	λ'_2	H'_1	H'_2	Obs.	λ'_1	λ'_2	H'_1	H'_2
h. m.		*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*Ft.*	*Ft.*
0 15	24	0 45	6 54	5.40	4.96	23	0 42	6 55	5.05	5.30	22	0 44	6 53	5.07	5.45	23	0 44	6 52	4.95	5.39
0 45	24	0 38	6 49	5.22	4.98	21	0 38	6 46	5.16	5.29	24	0 39	6 43	5.03	5.35	22	0 37	6 45	4.82	5.31
1 15	24	0 35	6 46	5.21	5.03	24	0 33	6 45	5.03	5.40	20	0 36	6 43	4.99	5.46	21	0 32	6 41	4.65	5.43
1 45	22	0 29	6 40	5.30	5.12	22	0 30	6 42	5.06	5.22	25	0 31	6 39	4.73	5.65	24	0 33	6 41	4.54	5.66
2 15	21	0 26	6 37	5.04	5.41	23	0 29	6 36	4.71	5.47	20	0 24	6 31	4.44	5.73	21	0 23	6 36	4.68	5.96
2 45	24	0 23	6 35	4.87	5.44	20	0 22	6 33	4.85	5.64	23	0 24	6 34	4.74	6.16	23	0 24	6 33	4.65	6.30
3 15	20	0 26	6 39	4.76	5.89	23	0 24	6 33	4.54	5.77	20	0 23	6 32	4.54	6.01	20	0 20	6 33	4.35	6.25
3 45	22	9 26	6 38	4.66	5.85	22	0 21	6 36	4.55	6.04	22	0 25	6 36	4.36	6.22	21	0 18	6 28	4.13	6.32
4 15	22	0 26	6 41	4.62	5.92	24	0 27	6 39	4.29	6.16	23	0 28	6 40	3.88	6.15	24	0 30	6 41	4.11	6.50
4 45	24	0 32	6 47	4.41	6.09	21	0 36	6 44	4.29	6.29	20	0 34	6 46	3.88	6.34	23	0 33	6 44	4.08	6.71
5 15	22	0 36	6 53	4.32	6.21	23	0 42	6 45	4.15	6.45	20	0 34	6 49	4.16	6.47	23	0 37	6 51	3.98	6.59
5 45	21	0 44	6 56	4.23	6.18	23	0 43	6 59	4.09	6.39	20	0 46	7 0	3.99	6.71	21	0 47	6 59	3.87	6.50
6 15	23	0 53	7 9	4.27	6.07	24	0 50	7 5	4.20	6.26	23	0 53	7 5	4.07	6.61	22	0 52	7 8	3.90	6.69
6 45	23	1 6	7 15	4.37	5.88	24	0 54	7 9	4.01	6.15	25	1 0	7 15	4.07	6.32	23	1 0	7 14	4.00	6.49
7 15	21	1 3	7 22	4.46	6.11	24	0 8	7 23	4.09	6.05	21	1 1	7 16	4.04	6.35	24	1 10	7 25	4.14	6.23
7 45	25	1 9	7 24	4.74	5.92	22	1 13	7 26	4.35	6.00	25	1 11	7 26	4.29	6.12	23	1 14	7 27	4.11	6.24
8 15	26	1 14	7 26	4.74	5.81	25	1 13	7 26	4.53	5.84	26	1 17	7 30	4.32	5.79	22	1 17	7 28	4.32	6.11
8 45	25	1 10	7 25	4.86	5.48	22	1 14	7 25	4.52	5.41	25	1 17	7 23	4.23	5.67	26	1 17	7 28	4.36	5.90
9 15	24	1 14	7 25	4.94	5.37	25	1 10	7 23	4.93	5.38	22	1 14	7 25	4.62	5.50	23	1 16	7 26	4.66	5.60
9 45	24	1 8	7 18	5.18	5.32	24	1 11	7 20	4.98	5.38	25	1 10	7 20	4.84	5.46	23	1 12	7 23	4.77	5.70
10 15	25	1 1	7 12	5.20	5.15	24	1 6	7 16	4.88	5.28	23	1 4	7 14	4.89	5.36	25	1 7	7 17	4.94	5.49
10 45	23	0 58	7 8	5.09	4.85	24	1 1	7 9	5.08	5.15	24	1 0	7 10	4.90	5.04	24	1 1	7 10	5.02	5.37
11 15	22	0 53	7 2	5.38	5.22	24	0 55	7 5	5.09	5.00	24	0 54	7 4	5.10	5.13	25	0 55	7 3	4.87	5.22
11 45	23	0 45	6 56	5.23	4.98	22	0 50	6 58	5.22	5.28	24	0 51	7 0	5.18	5.12	24	0 50	6 56	4.85	5.23
	554	0 47.5	6 59.9	4.854	5.552	553	0 47.8	6 59.5	4.652	5.692	546	0 48.3	6 58.9	4.515	5.840	550	0 48.7	6 59.5	4.448	5.966

$(\psi-\psi')$	$\eta_2=195°$					$\eta_2=210°$					$\eta_2=225°$					$\eta_2=240°$				
	Obs.	λ'_1	λ'_2	H'_1	H'_2	Obs.	λ'_1	λ'_2	H'_1	H'_2	Obs.	λ'_1	λ'_2	H'_1	H'_2	Obs.	λ'_1	λ'_2	H'_1	H'_2
h. m.		*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*Ft.*	*Ft.*
0 15	24	0 47	6 56	4.80	5.37	25	0 42	6 52	4.71	5.50	24	0 47	6 54	5.05	5.60	22	0 41	6 51	5.03	5.45
0 45	23	0 39	6 47	4.75	5.55	24	0 39	6 47	4.84	5.48	27	0 33	6 45	4.79	5.58	23	0 40	6 49	4.86	5.54
1 15	23	0 32	6 41	4.68	5.58	23	0 37	6 45	4.76	5.74	25	0 31	6 40	4.86	5.64	24	0 30	6 38	4.89	5.78
1 45	21	0 27	6 36	4.63	5.72	25	0 27	6 38	4.70	5.80	22	0 27	6 37	4.49	5.75	24	0 25	6 33	4.52	5.58
2 15	25	0 25	6 34	4.32	5.99	22	0 25	6 35	4.37	5.91	23	0 22	6 32	4.60	5.99	23	0 23	6 32	4.48	5.97
2 45	19	0 23	6 33	4.47	6.08	24	0 22	6 31	4.36	6.13	22	0 21	6 32	4.30	6.03	26	0 20	6 31	4.28	5.92
3 15	22	0 25	6 32	3.99	6.31	22	0 20	6 32	4.30	6.39	22	0 20	6 30	4.28	6.21	25	0 20	6 29	4.13	6.18
3 45	22	0 21	6 33	4.44	6.56	22	0 20	6 29	3.99	6.38	21	0 22	6 33	3.99	6.54	22	0 23	6 34	4.27	6.38
4 15	22	0 23	6 36	3.96	6.45	25	0 22	6 33	3.87	6.63	23	0 21	6 35	4.02	6.50	25	0 18	6 32	3.95	6.36
4 45	20	0 30	6 38	3.91	6.62	24	0 27	6 41	3.90	6.50	21	0 27	6 37	3.57	6.78	25	0 28	6 38	3.81	6.59
5 15	21	0 37	6 53	3.79	6.89	19	0 30	6 43	3.86	6.74	25	0 35	6 48	3.81	6.57	20	0 32	6 46	3.75	6.65
5 45	19	0 45	6 58	4.04	6.88	24	0 43	6 56	3.74	6.65	18	0 37	6 53	3.81	6.66	19	0 40	6 53	3.68	6.49
6 15	22	0 52	7 8	3.96	6.72	20	0 52	7 4	3.90	6.83	23	0 47	7 1	3.77	6.71	22	0 44	7 0	3.74	6.52
6 45	24	1 2	7 15	3.88	6.71	23	0 56	7 12	3.95	6.49	22	0 57	7 10	3.79	6.61	20	0 56	7 9	3.97	6.66
7 15	22	1 6	7 19	3.88	6.08	22	1 7	7 18	4.05	6.43	22	1 4	7 17	3.91	6.44	22	1 0	7 11	4.02	6.31
7 45	22	1 11	7 23	4.02	6.24	23	1 13	7 28	4.39	6.19	19	1 6	7 21	4.21	6.10	23	1 8	7 20	4.16	6.17
8 15	25	1 16	7 30	4.27	5.89	20	1 16	7 27	4.23	6.16	25	1 16	7 24	4.11	5.77	23	1 11	7 20	4.33	5.86
8 45	25	1 19	7 29	4.45	5.97	23	1 16	7 28	4.26	5.97	22	1 12	7 25	4.44	5.72	24	1 8	7 19	4.49	5.76
9 15	22	1 16	7 25	4.57	5.81	26	1 12	7 23	4.51	5.70	21	1 12	7 23	4.56	5.66	22	1 13	7 22	4.48	5.67
9 45	25	1 13	7 24	4.72	5.67	22	1 13	7 22	4.80	5.80	23	1 9	7 19	4.91	5.53	22	1 9	7 19	4.92	5.48
10 15	24	1 10	7 18	4.89	5.45	22	1 8	7 18	4.75	5.54	25	1 6	7 14	4.91	5.68	22	1 4	7 11	4.74	5.46
10 45	24	1 5	7 15	4.92	5.54	25	1 4	7 13	4.83	5.41	20	0 59	7 7	4.84	5.51	25	0 59	7 9	5.18	5.27
11 15	24	0 55	7 4	4.83	5.27	25	0 59	7 8	5.07	5.43	26	0 56	7 6	4.98	5.42	26	0 52	7 1	4.90	5.46
11 45	25	0 50	6 57	4.82	5.39	24	0 49	6 59	4.96	5.34	26	0 52	6 59	4.96	5.60	22	0 48	6 57	5.16	5.32
	545	0 48.7	6 59.3	4.374	6.014	555	0 47.5	6 58.4	4.379	6.047	547	0 45.8	6 56.7	4.398	6.025	552	0 44.7	6 55.2	4.406	5.953

TABLE III—*Containing average values belonging to the Arguments* $\psi - \psi' = \frac{1}{2}\eta_1$ *and* η_2—Continued.

COMBINED TRANSITS.

$\psi - \psi'$	$\eta_2 = 255°$					$\eta_2 = 270°$					$\eta_2 = 285°$					$\eta_2 = 300°$				
	Obs.	λ'_1	λ'_2	H'_1	H'_2	Obs.	λ'_1	λ'_2	H'_1	H'_2	Obs.	λ'_1	λ'_2	H'_1	H'_2	Obs.	λ'_1	λ'_2	H'_1	H'_2
h. m.		*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*Ft.*	*Ft.*
0 15	24	0 43	6 53	5.14	5.25	25	0 41	6 48	5.23	4.99	22	0 35	6 48	5 17	4 76	21	0 38	6 49	5.43	4.63
0 45	23	0 36	6 46	4.79	5.32	23	0 33	6 42	5.18	5.09	24	0 32	6 43	5.17	5.12	24	0 31	6 42	5.47	4.70
1 15	24	0 32	6 41	5.00	5.44	24	0 30	6 40	5.04	5.25	23	0 24	6 36	5.24	5.09	21	0 27	6 37	5.52	4.90
1 45	24	0 26	6 36	4.85	5.59	25	0 23	6 32	4.97	5.39	23	0 23	6 32	5.01	5.20	24	0 23	6 34	5.39	5.17
2 15	23	0 23	6 33	4.64	5.70	27	0 22	6 30	4.72	5.65	22	0 19	6 29	5.04	5.46	25	0 21	6 30	5.07	5.33
2 45	24	0 18	6 28	4.49	5.96	24	0 21	6 31	4.64	5.89	25	0 20	6 30	5.08	5.86	21	0 14	6 29	5.18	5.46
3 15	24	0 18	6 27	4.12	5.99	25	0 12	6 24	4.51	5.96	25	0 15	6 26	4.55	5.92	23	0 15	6 26	4.86	5.66
3 45	25	0 16	6 30	4.10	6 15	24	0 18	6 29	4.15	6.18	26	0 15	6 26	4.56	5.94	26	0 16	6 31	4.65	5.79
4 15	24	0 20	6 33	3.96	6.47	25	0 19	6 31	4.17	6.19	23	0 18	6 31	4.35	6.09	25	0 18	6 29	4.33	5.95
4 45	24	0 24	6 34	4.00	6.44	23	0 25	6 40	4.04	6.45	24	0 20	6 33	4.25	6.23	22	0 19	6 34	4.34	5.90
5 15	24	0 31	6 42	3.83	6.46	24	0 26	6 41	4.02	6.35	25	0 30	6 45	4.10	6.15	25	0 25	6 42	4.41	6.08
5 45	24	0 37	6 51	3.82	6.63	22	0 34	6 48	4.19	6.45	24	0 36	6 50	4.25	6.34	24	0 31	6 45	4.32	6.02
6 15	21	0 40	6 56	3.73	6.41	25	0 43	6 57	4.[illegible]	6.43	21	0 37	6 54	4.22	6.23	23	0 40	6 54	4.29	5.88
6 45	22	0 52	7 6	3.94	6.38	25	0 49	7 2	4.18	6.25	23	0 47	7 1	4.23	6.08	23	0 47	7 1	4.72	5.91
7 15	22	0 59	7 15	4.31	6.03	22	0 56	7 7	4.13	6.28	23	0 48	7 5	4.40	5.70	26	0 48	7 5	4.54	5.72
7 45	19	1 1	7 14	4.30	6.14	20	1 0	7 18	4.51	5.72	22	0 58	7 9	4.63	5.64	22	0 53	7 6	4.74	5.26
8 15	21	1 9	7 21	4.63	5.94	22	1 5	7 17	4.76	5.70	22	1 1	7 14	4.74	5.50	22	0 59	7 10	4.98	5.15
8 45	22	1 9	7 20	4.67	5.62	22	1 4	7 17	4.76	5.58	25	1 4	7 15	5.01	5.41	19	0 56	7 15	5.09	5.05
9 15	22	1 4	7 14	4.64	5.44	24	1 5	7 16	5.12	5.39	20	1 5	7 13	5.27	5.06	22	1 0	7 12	5.25	4.88
9 45	22	1 1	7 12	4.76	5.38	22	1 0	7 10	5.18	5.12	22	0 59	7 11	5.26	5.02	23	0 59	7 9	5.56	4.62
10 15	22	1 2	7 11	5.07	5.00	21	0 56	7 6	5.20	5.32	21	0 55	7 5	5.41	4.82	23	0 55	7 6	5.62	4.64
10 45	21	0 55	7 5	4.94	5.13	22	0 55	7 4	5.28	5.13	22	0 51	7 1	5.44	4.97	24	0 50	7 0	5.74	4.60
11 15	23	0 51	7 0	5.08	5.10	23	0 48	6 58	3.14	4.66	23	0 46	6 55	5.45	4.86	21	0 46	6 58	5.88	4.53
11 45	25	0 47	6 56	5.24	5.15	19	0 42	6 50	5.02	4.70	23	0 41	6 51	5.34	4 80	21	0 40	6 51	5.70	4.71
	549	0 42.3	6.535	4.502	5.797	556	0 40.3	6 51.6	4.676	5.630	553	0 38.3	6 50.1	4.840	5.510	550	0 37.1	6 49.8	5.045	5.281

$\psi - \psi'$	$\eta_2 = 315°$					$\eta_2 = 330°$					$\eta_2 = 345°$					$\eta_2 = 360°$				
	Obs.	λ'_1	λ'_2	H'_1	H'_2	Obs.	λ'_1	λ'_2	H'_1	H'_2	Obs.	λ'_1	λ'_2	H'_1	H'_2	Obs.	λ'_1	λ_2	H'_1	H'_2
h. m.		*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*Ft.*	*Ft.*		*h. m.*	*h. m.*	*Ft.*	*Ft.*
0 15	23	0 35	6 48	5.73	4.54	20	0 34	6 46	6.13	4.05	24	0 36	6 46	6.15	3.82	22	0 37	6 50	6.32	3.56
0 45	22	0 30	6 40	5.77	4.30	20	0 32	6 41	5.99	4.27	24	0 32	6 44	6.36	4.02	21	0 35	6 47	6.31	3.79
1 15	25	0 26	6 39	5.46	4.39	20	0 26	6 38	5.84	4.53	27	0 29	6 41	5.99	4.21	20	0 31	6 43	6.12	3.79
1 45	23	0 24	6 36	5.37	4.63	23	0 25	6 37	5.84	4.52	24	0 24	6 36	5.86	4.51	23	0 26	6 37	6.16	4.23
2 15	23	0 18	6 30	5.40	5.10	25	0 18	6 32	5.42	4.77	24	0 20	6 33	5.80	4.68	23	0 23	6 36	6.02	4.49
2 45	23	0 18	6 28	5.10	5.35	23	0 19	6 30	5.12	5.03	22	0 18	6 32	5.07	4.45	24	0 22	6 37	5.81	4.70
3 15	23	0 15	6 26	4.89	5.45	24	0 15	6 29	5.22	5.45	21	0 14	6 25	5.49	5.05	24	0 21	6 34	5.58	4.93
3 45	21	0 14	6 29	5.03	5.59	25	0 17	6 28	4.84	5.52	22	0 18	6 33	5.32	5.53	25	0 18	6 31	5.16	5.00
4 15	24	0 17	6 30	4.64	5.63	26	0 16	6 30	4.91	5.52	24	0 21	6 35	5.01	5.33	25	0 20	6 33	5.08	5.21
4 45	26	0 21	6 36	4.38	5.87	22	0 22	6 35	4.56	5.62	25	0 23	6 38	4.83	5 58	22	0 25	6 38	5.00	5.50
5 15	26	0 24	6 41	4.54	5.91	23	0 25	6 41	4.65	5.65	27	0 26	6 41	4.84	5.43	24	0 29	6 44	4.91	5.54
5 45	23	0 31	6 45	4.49	5.70	23	0 33	6 50	4.64	5.80	25	0 30	6 46	4.88	5.52	26	0 32	6 48	4.97	5.47
6 15	24	0 37	6 53	4.47	5.75	23	0 38	6 52	4.73	5.42	22	0 38	6 45	4.99	5.40	23	0 38	6 55	5.24	5.24
6 45	22	0 46	7 1	4.62	5.55	24	0 41	6 58	4.86	5.41	24	0 43	6 59	4.94	5.28	21	0 43	6 58	5.28	5.08
7 15	24	0 47	7 1	4.81	5.34	24	0 47	7 5	5.03	5.16	23	0 47	7 2	5.18	5.14	23	0 44	7 2	5.37	5.07
7 45	24	0 53	7 9	5.12	5.37	23	0 53	7 5	5.22	4.91	23	0 51	7 8	5.51	4.92	25	0 53	7 8	5.46	4.86
8 15	24	0 56	7 11	5.23	4.90	22	0 55	7 6	5.31	4.78	24	0 51	7 6	5.51	4.45	24	0 55	7 9	5.71	4.50
8 45	23	0 55	7 8	5.30	4.71	24	0 56	7 12	5.66	4.46	21	0 55	7 7	5.67	4.40	22	0 56	7 8	5.91	4.26
9 15	21	0 55	7 8	5.55	4.36	23	0 53	7 7	5.62	4.36	22	0 53	7 7	5.86	3.98	22	0 53	7 6	6.00	4.09
9 45	19	0 54	7 7	5.80	4.36	23	0 52	7 4	5.92	4.15	23	0 52	7 5	6.21	3.88	22	0 53	7 5	6.20	3.78
10 15	21	0 54	7 5	5.56	4.35	20	0 48	7 2	6.04	3.87	23	0 49	7 2	6.11	3.89	22	0 47	7 3	6.58	3.78
10 45	22	0 46	7 0	6.06	4.03	22	0 43	7 0	6.07	4.16	20	0 46	7 0	6.40	3.56	22	0 45	7 0	6.62	3.74
11 15	22	0 45	6 55	6.04	4.40	22	0 41	6 53	6.07	3.87	20	0 43	6 55	6.24	3.60	23	0 46	6 58	6.41	3.59
11 45	24	0 41	6 50	5.81	4.22	22	0 41	6 53	6.10	3.96	22	0 38	6 49	6.31	3.61	23	0 41	6 54	6.61	3.31
	554	0 35.9	6 49.0	5.215	4.992	546	0 35.4	6 48.9	5.408	4 80.2	556	0 35.7	6 49.4	5.605	4.593	551	0 37.2	6 51.0	5.772	4.480

TABLE IV—*Containing average values belonging to the Arguments $\phi' = \frac{1}{2}\,\eta_8$ and Ω, or to the month and year.*

COMBINED TRANSITS.

Year.	JANUARY.				FEBRUARY.				MARCH.			
	λ'_1	λ'_2	H'_1	H'_2	λ'_1	λ'_2	H'_1	H'_2	λ'_1	λ'_2	H'_1	H'_2
	h. m.	*h. m.*	*Ft.*	*Ft.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*
1848	0 38	6 52	4.87	5.03	0 41	6 55	5.25	5.29	0 38	6 53	5.05	5.04
1849	0 33	6 46	4.89	4.83	0 41	6 55	5.17	4.87	0 40	6 54	5.14	4.86
1850	0 38	6 54	5.37	5.27	0 39	6 54	5.10	5.06	0 41	6 55	5.16	4.99
1851	0 40	6 54	5.01	4.92	0 40	6 53	4.81	4.83	0 43	6 56	5.18	5.05
1852	0 41	6 54	5.00	5.44	0 36	6 50	4.83	4.94	0 40	6 55	4.93	4.01
1853	0 31	6 46	5.57	5.67	0 38	6 53	5.19	5.15	0 32	6 45	5.07	4.88
1854	0 33	6 47	4.89	4.97	0 37	6 51	4.70	5.24	0 35	6 49	4.78	4.78
1855	0 35	6 48	4.97	5.28	0 39	6 58	5.29	5.16	0 44	6 56	4.96	5.01
1856	0 35	6 48	5.14	5.63	0 31	6 44	4.81	5.18	0 36	6 50	4.77	5.01
1857	0 34	6 46	5.21	5.43	0 42	6 54	4.69	5.25	0 40	6 53	4.88	4.88
1858	0 39	6 53	4.74	5.33	0 48	6 52	4.36	5.12	0 41	6 54	4.75	4.92
1859	0 34	6 50	4.69	5.24	0 35	6 51	4.89	5.31	0 40	6 54	4.90	5.44
1860	0 36	6 50	4.53	5.21	0 40	6 53	4.59	4.96	0 39	6 54	4.74	5.05
1861	0 38	6 53	5.01	5.30	0 41	6 55	4.61	4.94	0 38	6 52	4.98	5.04
1862	0 42	6 54	4.88	5.12	0 37	6 48	5.02	5.46	0 41	6 53	5.37	5.47
1863	0 42	6 52	4.64	5.14	0 40	6 49	4.54	4.89	0 45	6 55	4.66	5.11
1864	0 44	6 56	4.23	4.90	0 47	6 57	4.48	4.66	0 45	6 57	5.17	5.56
1865	0 39	6 42	5.21	4.96	0 53	6 47	5.21	5.12	0 44	6 54	5.12	4.95
1866	0 49	7 3	4.98	4.95	0 59	6 55	4.44	4.61	0 43	6 55	4.66	5.21
Mean	0 37.9	6 51.0	4.933	5.190	0 40.7	6 52.3	4.841	5.060	0 40.8	6 53.4	4.962	5.058

Year.	APRIL.				MAY.				JUNE.			
	λ'_1	λ'_2	H'_1	H'_2	λ'_1	λ'_2	H'_1	H'_2	λ'_1	λ'_2	H'_1	H'_2
	h. m.	*h. m.*	*Ft.*	*Ft.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*	*h. m.*	*h. m.*	*Ft.*	*Ft.*
1848	0 41	6 54	5.05	4.90	0 43	6 55	5.39	5.08	0 45	6 57	5.45	5.17
1849	0 44	6 56	4.92	4.70	0 46	6 58	5.10	5.07	0 50	7 0	5.39	5.41
1850	0 40	6 53	5.12	4.88	0 42	6 54	5.06	5.21	0 48	6 58	5.69	5.12
1851	0 46	6 57	5.31	5.33	0 43	6 54	4.98	5.09	0 45	6 54	5.19	5.43
1852	0 41	6 54	5.63	5.39	0 42	6 54	5.13	4.99	0 45	6 58	4.99	5.17
1853	0 39	6 52	5.00	4.97	0 42	6 54	5.05	5.16	0 45	6 56	5.02	5.07
1854	0 41	6 54	4.99	5.03	0 43	6 55	4.76	5.16	0 46	6 59	5.01	5.47
1855	0 42	6 55	4.81	4.95	0 42	6 54	5.15	5.46	0 42	6 56	4.93	5.34
1856	0 40	6 54	4.79	5.19	0 41	6 53	5.00	5.43	0 44	6 56	4.90	5.43
1857	0 39	6 51	5.08	5.36	0 43	6 57	4.89	5.24	0 49	7 1	5.10	5.45
1858	0 34	6 56	4.72	5.34	0 46	6 57	4.72	5.36	0 46	6 56	4.82	5.34
1859	0 39	6 51	4.89	6.31	0 40	6 52	4 88	5.11	0 41	6 51	4.83	4.93
1860	0 38	6 53	4.75	5.06	0 45	6 56	4.97	5.06	0 47	6 58	5.19	4.35
1861	0 44	6 56	5.36	5.42	0 42	6 54	5.18	5.34	0 45	6 56	4.98	5.28
1862	0 43	6 56	4.85	5.11	0 46	6 59	4.92	5.30	0 46	6 59	5.18	5.42
1863	0 37	6 48	4.96	5.36	0 45	6 55	5.21	5.46	0 49	6 58	5.20	5.34
1864	0 45	6 57	5.79	5.69	0 42	6 56	5.37	5.35	0 43	6 58	5.13	5.12
1865	0 46	6 59	5.14	5.12	0 47	7 0	5.46	5.58	0 51	7 6	5.19	5.25
1866	0 38	6 52	4.85	5.25	0 44	6 57	5.21	5.35	0 47	7 1	5.12	5.18
Mean	0 41.4	6 54.1	5.000	5.177	0 43.4	6 55.5	5.075	5.253	0 46.0	6 57.8	5.090	5.225

TABLE IV—*Containing average values belonging to the Arguments $\phi' = \frac{1}{2}\,\eta_5$ and Ω, or to the month and year*—Continued.

COMBINED TRANSITS.

Year.	JULY.				AUGUST.				SEPTEMBER.			
	λ'_1	λ'_2	H'_1	H'_2	λ'_1	λ'_2	H'_1	H'_2	λ'_1	λ'_2	H'_1	H'_2
	h. m.	h. m.	Ft.	Ft.	h. m.	h. m.	Ft.	Ft.	h. m.	h. m.	Ft.	Ft.
1847	0 43	6 57	5. 28	5. 06	0 44	6 56	5. 35	4. 93	0 46	6 58	5. 40	5. 35
1848	0 49	7 1	5. 32	5. 19	0 48	6 59	5. 29	5. 14	0 46	6 59	5. 28	5. 50
1849	0 54	7 3	5. 09	5. 24	0 54	7 5	5. 39	5. 43	0 48	6 59	5. 27	5. 37
1850	0 45	6 55	5. 20	5. 22	0 48	6 56	5. 38	5. 35	0 46	6 57	5. 37	5. 35
1851	0 45	6 57	5. 37	5. 36	0 45	6 55	5. 33	5. 18	0 46	6 57	5. 23	5. 22
1852	0 47	6 59	4. 95	5. 11	0 48	7 0	5. 09	5. 23	0 48	6 58	5. 35	5. 49
1853	0 47	6 58	5. 04	5. 43	0 48	6 57	5. 16	5. 86	0 42	6 55	5. 07	5. 63
1854	0 44	6 55	4. 87	5. 28	0 43	6 54	5. 00	5. 39	0 43	6 55	5. 03	5. 52
1855	0 45	6 57	5. 09	5. 28	0 42	6 54	5. 15	5. 42	0 42	6 55	5. 17	5. 80
1856	0 46	6 54	5. 05	5. 56	0 44	6 57	5. 29	5. 91	0 42	6 53	5. 47	5. 73
1857	0 53	6 59	5. 07	5. 56	0 40	6 51	4. 76	5. 90	0 43	6 53	4. 90	5. 74
1858	0 46	6 56	5. 02	5. 45	0 46	6 54	5. 03	5. 33	0 43	6 53	4. 87	5. 33
1859	0 42	6 54	5. 04	5. 01	0 42	6 51	5. 12	4. 99	0 41	6 52	4. 98	5. 16
1860	0 49	7 2	4. 94	5. 24	0 44	6 56	4. 96	5. 17	0 45	6 57	4. 75	5. 05
1861	0 49	7 1	4. 92	5. 23	0 48	7 1	4. 88	5. 29	0 46	6 57	4. 84	5. 16
1862	0 49	7 1	5. 20	5. 44	0 47	6 58	5. 00	5. 16	0 43	6 55	4. 91	5. 06
1863	0 47	6 57	5. 19	5. 14	0 48	7 0	5. 25	5. 05	0 53	7 4	4. 99	5. 24
1864	0 49	7 3	5. 01	5. 19	0 54	7 10	4. 88	4. 90	0 47	7 3	4. 94	5. 13
1865	0 52	7 6	4. 91	5. 06	0 50	7 5	4. 83	5. 06	0 50	7 6	4. 91	5. 01
Mean	0 47. 6	6 58. 7	5. 082	5. 266	0 46. 5	6. 57. 8	5. 113	5. 3[illegible]0	0 45. 3	6 57. 2	5. 091	5. 360

Year.	OCTOBER.				NOVEMBER.				DECEMBER.			
	λ'_1	λ'_1	H'_1	H'_2	λ'_1	λ'_2	H'_1	H'_2	λ'_1	λ'_2	H'_1	H'_2
	h. m.	h. m.	Ft.	Ft.	h. m.	h. m.	Ft.	Ft.	h. m.	h. m.	Ft.	Ft.
1847	0 44	6 56	5. 22	5. 23	0 41	6 57	5. 40	5. 38	0 41	6 55	5. 17	5. 18
1848	0 44	6 57	5. 30	5. 72	0 40	6 54	5. 07	5. 39	0 37	6 52	5. 23	5. 48
1849	0 43	6 55	5. 76	5. 64	0 38	6 51	5. 76	5. 46	0 41	6 55	5. 36	5. 16
1850	0 41	6 52	5. 21	5. 25	0 40	6 53	5. 16	5. 18	0 41	6 54	5. 30	5. 21
1851	0 41	6 55	5. 31	5. 30	0 37	6 51	5. 27	5. 40	0 35	6 49	4. 93	5. 20
1852	0 40	6 53	5. 31	5. 85	0 42	6 55	5. 34	5. 68	0 32	6 47	5. 30	5. 45
1853	0 37	6 49	4. 86	5. 37	0 33	6 48	5. 21	5. 23	0 36	6 51	5. 34	5. 39
1854	0 38	6 43	5. 09	5. 70	0 38	6 51	5. 19	5. 52	0 40	6 54	5. 03	5. 26
1855	0 36	6 49	5. 16	5. 77	0 35	6 48	4. 97	5. 64	0 30	6 45	4. 93	5. 34
1856	0 41	6 53	5. 17	5. 80	0 45	6 47	5. 17	5. 71	0 41	6 42	5. 21	5. 25
1857	0 39	6 51	5. 34	5. 77	0 38	6 51	5. 15	5. 37	0 39	6 54	4. 77	5. 07
1858	0 38	6 50	5. 02	5. 62	0 37	6 49	5. 38	5. 37	0 38	6 36	4. 90	5. 25
1859	0 40	6 52	4. 90	5. 42	0 40	6 53	4. 83	5. 42	0 39	6 50	4. 79	5. 58
1860	0 44	6 56	4. 83	5. 18	0 43	6 57	5. 08	5. 63	0 40	6 54	4. 93	5. 37
1861	0 46	6 59	4. 99	5. 23	0 47	6 59	5. 31	5. 43	0 43	6 55	4. 84	4. 94
1862	0 43	6 53	5. 00	5. 28	0 44	6 52	4. 97	5. 16	0 42	6 53	4. 72	5. 00
1863	0 53	7 3	5. 15	5. 52	0 41	6 52	5. 02	5. 54	0 42	6 53	4. 84	5. 36
1864	0 48	7 2	5. 05	5. 26	0 41	6 57	5. 14	5. 12	0 36	6 49	5. 10	5. 10
1865	0 43	6 58	5. 04	5. 04	0 52	7 7	5. 41	5. 24	0 43	6 57	5. 19	4. 96
Mean	0 42. 0	6 54. 5	5. 143	5. 469	0 40. 6	6 53. 3	5. 202	5. 425	0 38. 7	6 50. 8	5. 046	5. 240

THE CONSTANT OR MEAN TIDE.

27. From the footings of Tables I and II we get the following table of average values of all the observations contained within certain limits of the argument $(\psi-\psi')$, and corresponding to the given average of the argument. These values, consequently, are independent of the effects depending upon any of the other arguments, and their inequalities depend only upon the argument $(\psi-\psi')$.

TABLE V.

UPPER TRANSITS.						LOWER TRANSITS.						COMBINED TRANSITS.					
Obs.	$(\psi-\psi')$	λ_1	λ_2	H_1	H_2	Obs.	$(\psi-\psi')$	λ_3	λ_4	H_3	H_4	Obs.	$(\psi-\psi')$	λ'_1	λ'_2	H'_1	H'_2
	h. m.	h. m.	h. m.	Ft.	Ft.		h. m.	h. m.	h. m.	Ft.	Ft.		h. m.	h. m.	h. m.	Ft.	Ft.
273	0 15.2	0 40.3	6 50.3	5.63	4.58	277	0 15.7	0 40.4	6 50.8	5.64	4.62	550	0 15.4	0 40.3	6 50.5	5.63	4.60
275	0 44.8	0 34.6	6 44.5	5.51	4.71	275	0 45.2	0 35.1	6 45.9	5.59	4.69	550	0 45.0	0 34.8	6 45.2	5.55	4.70
264	1 14.4	0 30.9	6 41.4	5.46	4.73	263	1 14.7	0 30.6	6 42.3	5.46	4.84	527	1 14.6	0 30.8	6 41.8	5.46	4.78
285	1 44.4	0 26.4	6 37.4	5.31	4.95	274	1 44.8	0 27.1	6 37.9	5.36	4.94	559	1 44.6	0 26.7	6 37.6	5.33	4.95
283	2 15.6	0 23.9	6 34.4	5.20	5.19	279	2 14.6	0 22.8	6 34.0	5.14	5.17	562	2 15.1	0 23.4	6 34.2	5.17	5.18
269	2 44.6	0 20.7	6 32.4	5.05	5.32	268	2 44.6	0 21.3	6 33.4	5.09	5.33	537	2 44.6	0 21.0	6 32.9	5.07	5.32
280	3 15.8	0 19.8	6 31.8	4.92	5.55	285	3 14.5	0 19.4	6 31.4	4.89	5.55	565	3 15.2	0 19.6	6 31.6	4.90	5.55
280	3 44.2	0 20.3	6 32.6	4.74	5.71	281	3 45.6	0 20.3	6 33.9	4.74	5.73	561	3 44.9	0 20.3	6 33.2	4.74	5.72
283	4 15.9	0 23.2	6 36.7	4.58	5.88	283	4 14.8	0 22.6	6 36.3	4.58	5.81	566	4 15.3	0 22.9	6 36.5	4.58	5.85
283	4 44.8	0 26.4	6 40.0	4.50	5.91	272	4 45.8	0 27.6	6 42.2	4.48	5.99	555	4 45.3	0 27.0	6 41.1	4.49	5.95
283	5 15.6	0 32.3	6 47.8	4.48	5.97	273	5 14.3	0 32.0	6 47.2	4.48	5.99	556	5 15.0	0 32.1	6 47.5	4.48	5.98
288	5 44.3	0 37.9	6 52.8	4.46	6.06	271	5 45.0	0 39.1	6 53.8	4.39	6.00	559	5 44.7	0 38.5	6 53.3	4.43	6.03
276	6 15.5	0 45.9	7 0.9	4.46	6.03	291	6 14.0	0 44.6	7 0.2	4.47	5.96	567	6 14.7	0 45.3	7 0.6	4.46	6.00
283	6 44.2	0 50.8	7 6.3	4.54	5.79	289	6 46.0	0 52.6	7 7.0	4.51	5.85	572	6 45.1	0 51.7	7 6.6	4.52	5.82
271	7 15.4	0 58.4	7 13.1	4.62	5.72	278	7 14.8	0 56.4	7 11.6	4.64	5.55	549	7 15.1	0 57.4	7 12.4	4.63	5.63
284	7 44.2	1 1.0	7 16.1	4.84	5.49	273	7 45.2	1 2.5	7 17.0	4.81	5.52	557	7 44.7	1 1.7	7 16.5	4.82	5.50
281	8 15.8	1 5.9	7 18.6	4.87	5.33	287	8 14.6	1 4.6	7 17.5	4.95	5.31	568	8 15.2	1 5.3	7 18.0	4.91	5.32
280	8 44.5	1 4.8	7 17.1	5.22	5.06	275	8 45.9	1 5.4	7 18.2	5.06	5.10	555	8 45.2	1 5.1	7 17.6	5.14	5.08
282	9 15.2	1 4.8	7 16.2	5.21	4.94	272	9 15.5	1 3.6	7 16.5	5.34	4.90	554	9 15.3	1 4.2	7 16.3	5.27	4.92
276	9 44.9	1 1.5	7 12.9	5.49	4.79	268	9 45.4	1 2.6	7 13.8	5.42	4.88	544	9 45.1	1 2.0	7 13.3	5.46	4.83
275	10 15.0	0 59.1	7 9.8	5.50	4.80	276	10 14.7	0 57.4	7 9.7	5.61	4.67	551	10 14.9	0 58.2	7 9.8	5.55	4.73
280	10 44.3	0 53.7	7 4.3	5.72	4.58	264	10 45.5	0 53.8	7 4.8	5.59	4.64	544	10 44.9	0 53.7	7 4.5	5.66	4.61
278	11 15.3	0 49.0	6 59.7	5.68	4.50	280	11 15.1	0 47.2	6 59.8	5.68	4.55	558	11 15.2	0 48.1	6 59.7	5.68	4.53
268	11 45.1	0 45.4	6 55.3	5.67	4.58	269	11 45.7	0 44.2	6 54.8	5.68	4.50	537	11 44.7	0 44.8	6 55.0	5.67	4.54
	Means..	0 42.37	6 54.67	5.070	5.257		Means..	0 42.22	6 55.00	5.062	5.257		Means..	0 42.29	6 54.84	5.066	5.257

In the footings of this table the inequalities having the argument $(\psi-\psi')$ are also eliminated, and we have results belonging to the mean tide. Since the diurnal tide depends upon φ, it is also eliminated, and we have left only the constant part of the other oscillations.

With the preceding mean values of λ'_1 and λ'_2 we get from (44), supplying the omitted constant of 2 days,

$$B_0=\tfrac{1}{2}(2^d\,0^h\,42^m.29+2^d\,6^h\,54^m.84-6^h\,12^m.62)=2^d\,0^h\,42^m.25 \tag{56}$$

which is *the mean establishment of the port* belonging to the assumed transit. In order to reduce this to the transit immediately preceding high water, we must add the constant part of k (34), putting $n=3$, and we thus get

$$B_0=2^d\,0^h\,42^m.25-1^d\,13^h\,13^m.14=0^d\,11^h\,26^m.53$$

From the first of (37) we get, since $L_3=B_0$ in this case,

$$\left\{\begin{array}{l} q_1=0^h\ 42^m.37-0^h\ 42^m.25=0^m.12 \\ q_2=6\ \ 54.67-0\ \ 42.25=\tfrac{1}{2}\pi-0^m.20 \\ q_3=0\ \ 42.22-0\ \ 42.25=-0^m.03 \\ q_4=6\ \ 55.00-0\ \ 42.25=\tfrac{1}{2}\pi+0^m.13 \end{array}\right. \tag{57}$$

in which $\pi=12$ lunar hours or $12^h\,25^m.24$ in solar time. Hence *all the intervals between high and low and low and high waters in the mean tide are almost exactly one-fourth of a lunar day.*

From the last two of (42) we get

$$(58)\quad \begin{cases} K_3 \cos 3\,\Delta' = \frac{1}{2}(5.070 - 5.062) = .004 \\ K_3 \sin 3\,\Delta' = \frac{1}{2}(5.257 - 5.257) = .000 \end{cases}$$

Hence $\Delta'=0$ and $K_3=.004$ ft. This is the value of the constant or mean tertio-diurnal tide, and may be regarded as falling within the limits of the errors of observation, and consequently insensible.

With the preceding values of K_3, which is the constant and principal part of A_3, and q_n, the terms in the first of (42) are entirely insensible. We therefore obtain from (45), with the preceding mean values of H'_1 and H'_2,

$$(59)\quad H'_0 = \tfrac{1}{2}(25.066 + 15.257) = 20.161 \text{ ft.}$$

for the mean height of the sea above the assumed zero of the tide-gauge. This, however, is not necessarily the same as the mean level obtained from observations made frequently at all times during the day, unless the tides follow the law of sines and cosines, or at least the parts above and below the mean level are symmetrical. It is simply the mean of the heights of high and low waters.

We obtain from the second of (42), since the terms depending upon K_3 are insensible,

$$(60)\quad K_2 = \tfrac{1}{2}(25.066 - 15.257) = 4.904 \text{ ft.}$$

for *the coefficient of the average or mean semi-diurnal tide.* Consequently the mean range is 9.808 ft.

With the preceding values of K_3, Δ_1', and K_2, (43) gives

$$q_1 = 0, \qquad q_2 = \tfrac{1}{2}\pi, \qquad q_3 = -0^m.13, \qquad q_4 = \tfrac{1}{2}\pi + 0^m.13$$

These values from the formulæ depending upon the heights are almost exactly the same as those obtained above from the observed times alone, (57).

THE SEMI-MONTHLY INEQUALITY.

28. If from each of the values of λ'_1, in the preceding table, we subtract $B_0+q_1=0^h\ 42^m.29$, omitting the constant two days, and from each value of λ_2' we subtract $B_0+q_2-k=6^h\ 54^m.84 +0^m.4 \cos \eta_1$, and call the differences δL, (46) and (47) will give, with these values of δL and the corresponding values of the argument $\eta_1=2(\psi-\psi')$, forty-eight equations of condition of the form

$$\delta L = M_1 \sin \eta_1 + N_1 \cos \eta_1 + M_{10} \sin \eta_{10} + N_{10} \cos \eta_{10}$$

the angles η_1 and η_{10} being the only ones included in the same argument. The tabular values of η_1 must be reduced to the time of low water for the twenty-four conditions obtained, from the low waters, by adding the mean change of η_1 from high to low water, which in this case is $25^m.24 +0^m.4 \cos \eta_1$, the small term $0^m.4 \cos \eta_1$ being an inequality in the moon's motion depending upon the argument of variation, which is the same as η_1 or $2(\psi-\psi')$. With these forty-eight equations we obtain, by the method of least squares,

$$M_1 = -22^m.25, \quad N_1 = 0^m.01, \quad M_{10} = 1^m.96, \quad N_{10} = -0^m.37$$

These values satisfy the forty-eight conditions, with an average residual of $0^m.35$ and a maximum residual of $1^m.3$. The residuals do not indicate any sensible term depending upon $3\eta_1$. With these values (48) gives

$$(60)\quad \begin{cases} B_1 = -22^m.5, & \epsilon_1 = 0^\circ \\ B_{10} = 2^m.0, & \epsilon_{10} = 5^\circ \end{cases}$$

These comprise the constants belonging to two of the terms of the expression of L_2, (26).

From (28) we get

$$(61)\quad \tau_1 = B_0 = 2^d.03$$

for *the age of the tide from the times.*

If, from each value of H'_1 in the preceding table, we subtract $H'_0+K_2=25.066$ ft., (59) and (60), and also from each value of H'_2 we subtract $H'_0-K_2=15.257$ ft., and call the residuals δH, (50) gives forty-eight equations of the form

$$\delta H = K_0 (M_1 \cos \eta_1 + N_1 \sin \eta_1) \pm K_2 (M_1 \cos \eta_1 + N_1 \sin \eta_1 + M_{10} \cos \eta_{10} + N_{10} \sin \eta_{10})$$

in which the minus sign belongs to the conditions obtained from low waters, and the tabular values of η_1 for these conditions must be reduced to the time of low water as above. With these conditions we obtain, by the method of least squares,

$$(62)\quad \begin{cases} K_0 M_1 = -0.059 \text{ ft.}, & K_2 M_1 = +0.670 \text{ ft.}, & K_2 M_{10} = -0.023 \text{ ft.} \\ K_0 N_1 = 0.000 \text{ ft.}, & K_2 N_1 = -0.124 \text{ ft.}, & K_2 N_{10} = +0.001 \text{ ft.} \end{cases}$$

These values satisfy the conditions with an average residual of .025 foot and a maximum of .06 foot. The residuals do not indicate any sensible term depending upon the angle $3\eta_1$ in the oscillations of the third kind, as may be also inferred from theory.

With the preceding values (49) gives

$$(63)\qquad \begin{cases} K_0 R_1 = -0.059 \text{ ft.}, & R_{(0,1)} = 0.504, & a_{(0,1)} = 0 \\ K_2 R_1 = +0.681 \text{ ft.}, & R_{(2,1)} = 0.1388, & a_{(2,1)} = -10^\circ 29' \\ K_2 R_{10} = -0.023 \text{ ft.}, & R_{(2,10)} = -0.0047, & a_{(2,10)} = -2^\circ \end{cases}$$

These are the constants of two of the terms in the expression of A_2 and of one of the terms of A_0, (24).

In obtaining the values of R from K R the values of K_0 and K_2, (31) and (60), have been used. It will be remembered that R expresses the ratio of the inequality to the mean tide in each kind of oscillation. As the inequality $R_{(2,10)}$ of the second degree is scarcely sensible, it is not probable that there are sensible inequalities of the third degree.

From (28) we get, expressing the value of a_1 in terms of the radius,

$$(64)\qquad \tau_1 = 2^d.03 - \frac{.183}{.426} = 1^d.60$$

for *the age of the tide from the heights.*

INEQUALITY DEPENDING UPON THE MOON'S MEAN ANOMALY.

29. From the footings of Table III we get the following table of average values of all the observations contained within the limits of each of the twenty-four equal divisions of η_2, in which the middle of the division is taken as the value of η_2 belonging to the averages. In these footings the inequality depending upon $(\psi - \psi')$ is eliminated, and they consequently contain only the inequality depending upon η_2:

TABLE VI.

Obs.	η_2	λ'_1	λ'_2	H'_1	H'_2
	°	h. m.	h. m.	Feet.	Feet.
561	15	0 37.9	6 52.3	5.894	4.426
546	30	0 39.0	6 53.6	5.882	4.378
555	45	0 40.1	6 54.8	5.850	4.422
552	60	0 40.8	6 56.0	5.771	4.554
551	75	0 42.0	6 56.2	5.566	4.692
548	90	0 43.4	6 57.0	5.376	4.917
559	105	0 44.0	6 57.1	5.1[illegible]2	5.112
565	120	0 45.0	6 58.4	5.015	5.372
554	135	0 47.5	6 59.9	4.854	5.552
553	150	0 47.8	6 59.5	4.652	5.692
546	165	0 48.3	6 58.9	4.515	5.840
550	180	0 48.7	6 59.5	4.448	5.966
545	195	0 48.7	6 59.3	4.374	6.014
555	210	0 47.5	6 58.4	4.379	6.047
547	225	0 45.8	6 56.7	4.398	6.025
552	240	0 44.7	6 55.2	4.406	5 953
549	255	0 42.3	6 53.5	4.502	5.797
556	270	0 40.3	6 51.6	4.676	5.630
553	285	0 38.3	6 50.1	4.840	5.510
550	300	0 37.1	6 49.8	5.045	5.281
554	315	0 35.9	6 49.0	5.215	4.992
546	330	0 35.4	6 48.9	5.408	4.802
556	345	0 35.7	6 49.4	5.605	4.593
551	360	0 37.2	6 51.0	5.772	4.480
13,254	Means.	0 42.24	6 54.84	5.068	5.252

From the footings of this table the constants of the mean tide might also be obtained, as in the preceding case, but they would not differ sensibly, as may be seen by comparing the footings of the

two tables. If from each value of λ'_1 in the preceding table we subtract $B_0+q_1=0^h\ 42^m.24$, as obtained from the preceding table, and from each value of λ'_2 we take $B_0+q_2-k=6^h\ 54^m.84 +1^m.5 \cos \eta_2$, putting δL for the residuals, (46) and (47) give forty-eight equations of the form

$$\delta L = M_2 \sin \eta_2 + N_2 \cos \eta_2 + M_{11} \sin \eta_{11} + N_{11} \cos \eta_{11}$$

the angles η_2 and η_{11} being included in the same argument. In this case the value of k (34) includes the constant and the inequality depending upon η_2; the value of n being $\frac{1}{2}$ as before. In this case, to obtain the values of η_2 belonging to low water, we must add $3^\circ.3+0^\circ.5 \cos \eta_2$ to the tabular values of η_2 given for high water. These conditions give, by the method of least squares,

$$M_2=3^m.3, \qquad N_2=-5^m.2, \qquad M_{11}=0^m.6, \qquad N_{11}=0^m.8$$

These values satisfy the conditions, with an average residual of $0^m.3$ and a maximum residual of $0^m.9$. With these values (48) gives

$$\text{(65)} \qquad \begin{cases} B_2 = 6^m.2, & \epsilon_2 = \ \ 72^\circ.7 \\ B_{11} = 1^m.0, & \epsilon_{11} = -23^\circ \end{cases}$$

The preceding are the values of ϵ_2 and ϵ_{11} when η_2 is given for a time two lunar days after the transit C (§ 26). In order to reduce them to the case in which η_2 is given for the time of transit C, we must subtract the mean changes of η_2 and η_{11} in two lunar days, which is $27^\circ.1$ in the former and twice that, or $54^\circ.2$, in the latter. Hence we get, in this case,

$$\text{(66)} \qquad \epsilon_2 = 45^\circ.6, \qquad \epsilon_{11} = -77^\circ$$

The preceding are the constants belonging to two more of the terms in the expression of L_2 (26).

If, now, as in the preceding case, we subtract H'_0+K_2 from each value of H'_1 in the preceding table, and H'_0-K_2 from each value of H'_2, with these forty-eight residuals and the corresponding values of η_2, (50) gives forty-eight equations of the form

$$\delta H = K_0(M_2 \cos \eta_2 + N_1 \sin \eta_2) \pm K_2(M_2 \cos \eta_2 + N_2 \sin \eta_2 + M_{11} \cos \eta_{11} + N_{11} \sin \eta_{11})$$

in which the minus sign belongs to low waters. From these forty-eight conditions we obtain

$$\begin{array}{lll} K_0 M_2 = -0.033 \text{ ft.}, & K_2 M_2 = +0.771 \text{ ft.}, & K_2 M_{11} = +0.051 \text{ ft.} \\ K_0 N_2 = -0.014 \text{ ft.}, & K_2 N_2 = +0.204 \text{ ft.}, & K_2 N_{11} = +0.014 \text{ ft.} \end{array}$$

With these values (49) gives

$$\text{(67)} \qquad \begin{cases} K_0 R_2 = -0.036 \text{ ft.}, & R_{(0,2)} = 0.308, & \alpha_{(0,2)} = 38^\circ \\ K_2 R_2 = +0.797 \text{ ft.}, & R_{(2,2)} = 0.1624, & \alpha_{(2,2)} = 29^\circ\ 51' \\ K_2 R_{11} = +0.053 \text{ ft.}, & R_{(2,11)} = 0.0107, & \alpha_{(2,11)} = 45^\circ \end{cases}$$

These values satisfy the conditions, with an average residual of 0.020 ft. and a maximum residual of 0.049 ft. These are a part of the constants belonging to the terms in the expressions of A_0 and A_2 (24).

In order to reduce the preceding values of the angle of epoch to transit C, we must subtract $27^\circ.1$ from the first two and $54^\circ.2$ from the last one.

From (28) we get, with the reduced value of $\alpha_2 = 29^\circ.9 - 27^\circ.1$,

$$\text{(68)} \qquad \tau_2 = 2^d.03 + \frac{.049}{.229} = 2^d.24$$

INEQUALITY DEPENDING UPON THE MOON'S LONGITUDE.

30. By taking the average of all the values of λ and H of each transit in Tables I and II, and then taking the half sum and the half difference of the values of the two transits, we get the following table of average values belonging to the given longitude, from which the inequality depending upon $(\psi-\psi')$ is eliminated, and consequently they contain only the inequality depending upon the moon's longitude.

TABLE VII.

Obs.	Combined transits.					The differences of transits.			
	ϕ	λ'_1	λ'_2	H'_1	H'_2	$(\lambda_1-\lambda_3)$	$(\lambda_2-\lambda_4)$	(H_1-H_3)	(H_2-H_4)
	°	h. m.	h. m.	Ft.	Ft.	m.	m.	Ft.	Ft.
555	7.5	0 41.7	6 53.4	5.182	5.123	+2.0	−2.8	−0.486	+0.234
553	22.5	0 43.5	6 55.1	5.148	5.145	1.5	4.0	0.719	0.391
555	37.5	0 44.8	6 57.5	5.106	5.233	3.4	4.7	0.822	0.481
556	52.5	0 45.4	6 57.8	5.043	5.282	4.8	4.8	0.886	0.569
547	67.5	0 44.2	6 57.0	4.991	5.334	5.1	5.5	0.992	0.523
548	82.5	0 42.5	6 55.2	4.998	5.355	5.1	5.4	0.963	0.636
550	97.5	0 39.4	6 52.4	4.999	5.365	5.0	4.3	0.888	0.540
545	112.5	0 36.8	6 50.3	5.029	5.334	5.6	1.9	0.667	0.482
552	127.5	0 35.9	6 48.7	5.024	5.234	3.5	2.5	0.567	0.383
558	142.5	0 36.5	6 49.1	5.075	5.199	2.1	−2.2	−0.235	0.160
563	157.5	0 39.1	6 51.5	5.122	5.178	2.1	+0.1	+0.001	+0.042
553	172.5	0 43.0	6 54.4	5.131	5.168	+0.3	2.7	0.227	−0.068
566	187.5	0 45.2	6 56.9	5.131	5.157	−2.0	2.8	0.555	0.230
558	202.5	0 47.9	6 59.9	5.086	5.215	2.5	3.1	0.739	0.352
563	217.5	0 49.1	6 61.9	5.056	5.291	3.8	4.1	0.830	0.501
562	232.5	0 50.4	6 63.0	5.015	5.390	3.1	4.5	0.942	0.578
563	247.5	0 49.6	6 62.0	5.007	5.434	4.0	5.5	0.945	0.576
557	262.5	0 46.4	6 59.0	4.997	5.427	6.4	3.7	0.872	0.511
552	277.5	0 43.5	6 56.5	4.924	5.403	4.2	5.1	0.852	0.519
541	292.5	0 40.4	6 53.1	4.998	5.304	3.9	2.2	0.769	0.479
558	307.5	0 38.0	6 50.7	5.056	5.290	4.7	1.2	0.532	0.400
545	322.5	0 36.5	6 49.4	5.101	5.136	2.3	+0.1	0.328	0.206
569	337.5	0 37.4	6 50.3	5.168	5.097	1.6	−1.6	+0.042	−0.115
546	352.5	0 39.2	6 51.0	5.203	5.071	−1.5	−3.9	−0.291	+0.081
	Means.	0 42.35	6 54.83	5.067	5.255				

The inequalities in the values in the preceding table are affected by the tide produced by the small term in the moon's disturbing force depending upon the fourth power of the moon's distance. The expression of this tide, and also of the lunitidal interval, contains the angle φ, (33); and hence the expressions representing the inequalities in the preceding tabular values must contain such an angle. By proceeding in the same manner as in the preceding cases, we obtain from the preceding table forty-eight equations of the form,

$$\delta L = M'' \sin \varphi + N'' \cos \varphi + M_3 \sin \eta_3 + N_3 \cos \eta_3$$

These equations give

$$M'' = -2^m.1, \qquad N'' = -1^m.4, \qquad M_3 = 5^m.3, \qquad N_3 = 0^m.5$$

From these we get by (48),

$$(69) \qquad \begin{cases} B'' = 2^m.5, & \epsilon'' = -34^\circ \\ B_3 = 5^m.3, & \epsilon_3 = 6^\circ \end{cases}$$

These constants satisfy the conditions, with an average residual of $0^m.4$ and a maximum of $1^m.4$.

From the values of H'_1 and H'_2 in the preceding table we obtain, as in the preceding cases, from (50) forty-eight equations of the form

$$\delta H = K_0 (M_3 \cos \eta_3 + N_3 \sin \eta_3) \pm K_2 (M_3 \cos \eta_3 + N_3 \sin \eta_3 + M'' \cos \varphi + N'' \sin \varphi$$

From these forty-eight conditions we obtain

$$\begin{array}{lll} K_0 M_3 = -.021 \text{ ft.}, & K_2 M_3 = +.107 \text{ ft.}, & M'' = +.030 \\ K_0 N_3 = +.005 \text{ ft.}, & K_2 N_3 = -.012 \text{ ft.}, & N'' = +.007 \end{array}$$

With these values (49) gives

$$(70) \qquad \begin{cases} K_0 R_3 = -.022 \text{ ft.}, & R_{(0,3)} = .190 & \alpha_{(0,3)} = -14^\circ \\ K_2 R_3 = .109 \text{ ft.}, & R_{(2,3)} = .0225 & \alpha_{(2,3)} = -6^\circ\, 30' \\ K_2 R'' = .032 \text{ ft.}, & R'' = .0065 & \alpha'' = +13^\circ \end{cases}$$

Since the range of argument belonging to each group of observations is twice as great in this case as in the other cases, the coefficients of the inequalities, as obtained, are increased in the ratio of the sine to the arc of the half range of the groups of observations. An explanation of this small correction has been given in (§ 23). This very small correction is insensible in the other cases.

These constants satisfy the conditions, with an average residual of .016 ft. and a maximum of .057 ft. As the preceding inequalities of the first degree are so small, those of the second degree depending upon $2\eta_3$ must be very small and may be neglected.

From (28) we get

$$\tau_3 = 2^d.03 - \frac{.113}{.460} = 1^d.78 \tag{71}$$

Since the maximum of the small tide depending upon the fourth power of the moon's distance does not necessarily happen at the same time as that of the principal part of the semi-diurnal tide, the preceding value of $K_2 R''$ represents the height of that tide at the time of the high water of the resultant tide. Hence, putting

λ'' = the lunitidal interval of the small tide;
q'' = the time of the resultant high water after that of the mean semi-diurnal tide;
$K_2 a$ = the coefficient of the tide;

we have

$$1+R'' = \sqrt{1+a^2+2\,a\cos(L_2-\lambda'')} = 1 + a\cos(L_2-\lambda'') \text{ nearly}$$

$$\tan q'' = \frac{a\sin(L_2-\lambda'')}{1+a\cos(L_2-\lambda'')} = a\sin(L_2-\lambda'') \text{ nearly}$$

From the preceding values of B'' and ϵ'' and of R'' and α'', we get

$$q'' = -2^m.5\sin(\varphi+34^\circ)$$
$$R'' = .0065\sin(\varphi+77^\circ)$$

These values of q'' and R'' cannot satisfy the preceding equations unless the angles are the same, whereas they differ 43°. But since the coefficient $K_2 R''$ of the small tide from which the value of α'' has been determined is only a small fraction of an inch, the discrepancy may be regarded as falling within the limits of the errors of observation. Assuming that the angles are equal, we then have, at the time of the maximum, $q'' = -2^m.5$, and $R'' = .0065$.

With these values the preceding equations give

$$.0065 = \quad a\cos(L_2-\lambda'')$$
$$.0218 = -a\sin(L_2-\lambda'')$$

from which we get

$$a = .023, \qquad L_2 - \lambda'' = -73^\circ \tag{72}$$

Hence $K_2 a = 0.115$ ft. is the coefficient of the tide, and 73° expressed in solar time, which is about $2\frac{1}{2}$ hours, is the time the high water of this small tide precedes the time of the high water of the principal tide. Hence *the high water of this tide occurs at* $11^h\,26^m.5 - 2^h\,30^m = 8^h\,56^m.5$, *or about* 9 *o'clock in lunar time.* We also have in this case

$$B''_0 = 2^d\,0^h\,42^m - 2^h\,30^m = 1^d\,22^h\,12^m \tag{73}$$

for *the mean establishment.*

INEQUALITIES DEPENDING UPON THE SUN'S ANOMALY AND LONGITUDE.

31. From the means in the footings of Table IV we get the following table of average values, corresponding to the given values of v' and $2\varphi'$ belonging to the middle of each month:

TABLE VII.

Month.	′	$2\phi'$	λ'_1	λ'_2	H'_1	H'_2	$\frac{1}{2}(H'_1+H'_2)$	$\frac{1}{2}(H'_1-H'_2)$	$\delta H'_0$
	°	°	*h. m.*	*h. m.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
January	15	230	0 37.9	6 51.0	4.933	5.190	20.061	4.861	−.089
February	45	290	0 40.7	6 52.2	4.841	5.060	19.950	4.890	−.200
March	75	351	0 40.8	6 53.4	4.962	5.058	20.010	4.952	−.140
April	105	51	0 41.4	6 54.1	5.000	5.177	20.092	4.915	−.058
May	135	110	0 43.4	6 55.5	5.075	5.253	20.164	4.911	+.014
June	165	168	0 46.0	6 57.8	5.090	5.225	20.157	4.932	+.007
July	194	226	0 47.6	6 58.7	5.082	5.266	20.174	4.908	+.024
August	223	284	0 46.5	6 57.8	5.113	5.300	20.206	4.906	+.056
September	252	344	0 45.3	6 57.2	5.091	5.360	20.225	4.865	+.075
October	282	44	0 42.0	6 54.5	5.143	5.469	20.306	4.837	+.156
November	313	106	0 40.6	6 53.3	5.202	5.425	20.313	4.888	+.163
December	344	168	0 38.7	6 50.8	5.046	5.240	20.143	4.903	−.007
Means	....	....	0 42.6	6 54.9	5.058	5.252	20.150	4.897	....

From this table we obtain, as in preceding cases, twelve values of δL, which, together with the corresponding values of $v'=\eta_4$ and $2\varphi'=\eta_5$, in (46) and (47), give twelve equations of the form

$$\delta L = M_4 \sin \eta_4 + N_4 \cos \eta_4 + M_5 \sin \eta_5 + N_5 \cos \eta_5$$

From these we get, in the same manner as in preceding cases,

$$(74)\qquad \begin{cases} B_4 = -3^m.9, & \epsilon_4 = -73^\circ \\ B_5 = -0^m.6, & \epsilon_5 = -10^\circ \end{cases}$$

In the same way with the values of $\frac{1}{2}(H'_1 - H'_2)$, (50) gives twelve equations of the form

$$\delta H = K_2 (M_4 \cos \eta_4 + N_4 \sin \eta_4 + M_5 \cos \eta_5 + N_5 \sin \eta_5)$$

From these conditions we get

$$(75)\qquad \begin{cases} K_2 R_4 = 0.0378 \text{ ft.}, & R_4 = -.0077, & a_4 = -65^\circ \\ K_2 R_5 = 0.0093 \text{ ft.}, & R_5 = -.0019, & a_5 = -58^\circ \end{cases}$$

In the same manner we obtain from the values of $\frac{1}{2}(H'_1 + H'_2)$,

$$(76)\qquad \begin{cases} K_0 R_4 = 0.126 \text{ ft.}, & R_4 = 1.08, & a_4 = 254^\circ \\ K_0 R_5 = 0.073 \text{ ft.}, & R_5 = 0.62, & a_5 = 98^\circ \end{cases}$$

Since the arguments in the preceding table change so little from high to the following low water, $\frac{1}{2}(H'_1 + H'_2)$ may be taken as a normal value of the mean height, and $\frac{1}{2}(H'_1 - H'_2)$ as the coefficient or semi-range of the tide.

In the preceding table $\delta H'_0$ is the difference between any value of H'_0 and its mean value, and the column expresses the annual variation of mean level.

INEQUALITY DEPENDING UPON THE MOON'S NODE.

32. By summing the values of λ'_1, λ'_2, H'_1, and H'_2, and taking the averages so as to eliminate the annual inequalities, we obtain the following table of averages for each year, in which the value of ω belonging to the middle of the year is given:

TABLE VIII.

Year.	ω	λ'_1	λ'_2	H'_1	H'_2	$\frac{1}{2}(H'_1+H'_2)$	$\frac{1}{2}(H'_1-H'_2)$
	°	h. m.	h. m.	Feet.	Feet.	Feet.	Feet.
1848	156	0 42.5	6 55.7	5.21	5.24	20.22	4.99
1849	137	0 44.3	6 56.4	5.27	5.17	20.22	5.05
1850	118	0 42.4	6 54.6	5.21	5.17	20.19	5.02
1851	98	0 42.1	6 54.3	5.16	5.19	20.18	4.99
1852	79	0 41.8	6 54.8	5.15	5.30	20.22	4.93
1853	59	0 39.2	6 52.0	5.13	5.32	20.22	4.90
1854	40	0 40.0	6 53.1	4.98	5.28	20.11	4.83
1855	21	0 39.5	6 53.0	5.05	5.37	20.21	4.84
1856	2	0 40.2	6 51.0	5.04	5.49	20.21	4.78
1857	342	0 41.6	6 53.4	4.99	5.42	20.21	4.79
1858	323	0 41.8	6 52.2	4.86	5.33	20.10	4.77
1859	304	0 39.4	6 52.2	4.90	5.24	20.07	4.83
1860	285	0 42.5	6 55.5	4.86	5.11	19.99	4.88
1861	266	0 44.0	6 56.4	4.99	5.22	20.10	4.89
1862	246	0 43.6	6 55.1	5.00	5.25	20.12	4.88
1863	227	0 45.2	6 55.5	4.97	5.26	20.12	4.85
1864	207	0 45.1	6 58.7	5.02	5.16	20.09	4.93
1865	187	0 46.7	6 58.9	5.14	5.11	20.12	5.01
Means	....	0 42.6	6 54.9	5.048	5.249	20.150	4.897

In this case, as in the preceding one, the argument changes so slowly that we can take $\frac{1}{2}$ $(H'_1 + H'_2)$ as the mean level, and $\frac{1}{2}$ $(H'_1 - H'_2)$ as the mean range, corresponding to the given value of ω.

From the preceding values of λ'_1 and λ'_2, we obtain, in the same way as heretofore, eighteen equations of the form

$$\delta L = M_6 \sin \eta_6 + N_6 \cos \eta_6$$

which gives by (48),

(77) $$B_6 = -2^m.5, \qquad \epsilon_6 = -50^\circ$$

From the last column we obtain eighteen equations of the form

$$\delta H = M_6 \cos \eta_6 + N_6 \sin \eta_6$$

which, by (49), gives

(78) $$K_2 R_6 = -0.112 \text{ ft.}, \qquad R_6 = -.0235, \qquad a_6 = -11^\circ$$

INEQUALITIES DEPENDING UPON η_8 AND η_9.

33. If in Table III we combine all the values of λ'_1, λ'_2, H'_1, and H'_2, in which $\eta_1 + \eta_2 = 7^\circ.5$, and then all those in which $\eta_1 + \eta_2 = 22^\circ.5$, and so on; and likewise combine all those in which $\eta_1 - \eta_2 = 7^\circ.5$, and then all those in which $\eta_1 - \eta_2 = 22^\circ.5$, and so on, we get the following table of averages, corresponding to twenty-four values of the argument $\eta_1 + \eta_2 = \eta_8$, and also to twenty-four values of the argument $\eta_1 - \eta_2 = \eta_9$, in which the inequalities of all the other arguments are eliminated:

TABLE IX.

η_8	λ'_1	λ'_2	H'_1	H'_2	η_9	λ'_1	λ'_2	H'_1	H'_2
°	h. m.	h. m.	Feet.	Feet.	°	h. m.	h. m.	Feet.	Feet.
7.5	0 41.7	6 54.3	5.104	5.232	7.5	0 43.4	6 55.9	5.195	5.123
22.5	0 43.0	6 55.0	5.099	5.242	22.5	0 45.0	6 57.7	5.119	5.147
37.5	0 42.2	6 55.2	5.073	5.247	37.5	0 45.1	6 57.8	5.095	5.206
52.5	0 43.4	6 55.9	5.036	5.207	52.5	0 45.3	6 58.0	5.082	5.254
67.5	0 43.4	6 55.8	5.015	5.247	67.5	0 45.8	6 58.2	5.017	5.253
82.5	0 43.8	6 56.9	5.060	5.252	82.5	0 45.5	6 58.7	5.034	5.295
97.5	0 43.9	6 56.6	5.030	5.270	97.5	0 45.4	6 57.8	4.998	5.372
112.5	0 44.2	6 56.1	5.029	5.283	112.5	0 44.7	6 57.2	5.016	5.337
127.5	0 43.4	6 56.0	4.978	5.259	127.5	0 43.8	6 56.5	4.999	5.386
142.5	0 43.5	6 55.9	5.082	5.252	142.5	0 43.2	6 55.3	4.985	5.364
157.5	0 43.2	6 55.8	5.025	5.290	157.5	0 41.5	6 54.3	4.961	5.390
172.5	0 42.8	6 55.0	5.030	5.278	172.5	0 41.2	6 53.8	4.943	5.343
187.5	0 42.5	6 55.2	5.089	5.296	187.5	0 40.4	6 52.6	4.926	5.352
202.5	0 42.2	6 55.2	5.107	5.254	202.5	0 39.5	6 51.7	4.997	5.332
217.5	0 41.4	6 53.3	5.039	5.290	217.5	0 38.7	6 51.8	4.989	5.267
232.5	0 41.3	6 54.4	5.067	5.242	232.5	0 39.9	6 52.2	5.060	5.290
247.5	0 40.8	6 53.8	5.111	5.286	247.5	0 39.1	6 51.9	5.108	5.260
262.5	0 41.0	6 53.5	5.090	5.244	262.5	0 39.1	6 51.0	5.111	5.196
277.5	0 40.6	6 53.6	5.077	5.217	277.5	0 39.3	6 51.9	5.130	5.227
292.5	0 40.4	6 53.0	5.067	5.238	292.5	0 39.5	6 52.1	5.144	5.143
307.5	0 41.2	6 53.7	5.102	5.254	307.5	0 40.3	6 52.8	5.167	5.147
322.5	0 40.3	6 53.8	5.108	5.220	322.5	0 41.5	6 54.8	5.183	5.130
337.5	0 41.8	6 53.7	5.080	5.219	337.5	0 42.4	6 55.0	5.183	5.103
352.5	0 41.5	6 54.5	5.095	5.242	352.5	0 44.2	6 57.1	5.139	5.128
Means.	0 42.2	6 54.8	5.066	5.253	Means.	0 42.3	6 54.8	5.066	5.252

By the methods heretofore used, we obtain from these tabular results,

$$(79)\quad \begin{cases} B_8 = 1^m.5, & \varepsilon_8 = -25^\circ, & K_2 R_8 = .0265 \text{ ft.}, & R_8 = .0054, & \alpha_8 = -45^\circ \\ B_9 = 3^m.5, & \varepsilon_9 = 24^\circ, & K_2 R_9 = .1196 \text{ ft.}, & R_9 = .0240, & \alpha_9 = -21^\circ \end{cases}$$

As has been stated, the values of η_2 in Table III belong to a time two lunar days after transit C, and hence the values of the argument η_8 are too great for the assumed transit C, by the change of η_2 in that time. For the same the values of argument η_9 are too small by that amount. The preceding values of the epochs have been reduced to transit C by subtracting 27°.1 in the former case, and adding the same amount in the latter case.

In the same manner the constants might be found for the terms depending upon the arguments $\eta_1+\eta_3$ and $\eta_1-\eta_3$, or $\eta_2+\eta_3$ and $\eta_2-\eta_3$, but the effects depending upon these arguments must be still smaller than those depending upon η_8 and η_9. This one case will serve to show that these effects are of very little importance.

DIURNAL TIDE.

34. It has been found that the terms depending upon A_3 are insensible, and hence with the twenty-four values of (H_1-H_3) and (H_2-H_4) in Table V, (52) gives twenty-four sets of equations for determining the twenty-four values of A_1 and Δ, belonging to the twenty-four values of φ. With these values of A_1 and the corresponding values of φ in the table, (53) then gives twenty-four equations of condition for determining, by the method of least squares, the values of M and N, with which we then obtain, by (54),

$$(80)\qquad K_1 = -0.58 \text{ ft.}, \qquad \alpha = -19^\circ.7$$

for the coefficient of the diurnal tide and the value of the angle at the epoch.

From (28) we get, using the value of B_0 in (56),

$$(81)\qquad \tau = 2^d.03 - \frac{19^\circ.7}{13^\circ.18} = 0^d.504$$

for *the age of the diurnal tide,* 13°.18 being the daily motion of the moon in longitude.

The preceding twenty-four equations of conditions also give $\Delta = 31^\circ$. Expressing this value in solar time, we get from (37) $L_2 - L_1 = 2^h\ 8^m$ for *the time the high water of the diurnal tide precedes that of the semi-diurnal tide.*

We consequently have

(82) $$B_0 = 2^d\ 0^h\ 42^m - 2^h\ 8^m = 1^d\ 22^h\ 34^m$$

for *the mean establishment of the diurnal tide* belonging to transit C.

It is evident from (41) that $\frac{1}{2}(\lambda_1 - \lambda_3) = q_1$ and $\frac{1}{2}(\lambda_2 - \lambda_4) = \frac{1}{2}\pi - q_2$. With the preceding values of K_1 and Δ_1 and K_3 (60), we get from (55), expressing arcs in time,

$$q_1 = +\ 1^m.8 \sin(\varphi - a)$$
$$\tfrac{1}{2}\pi - q_2 = -\ 3^m.0 \sin(\varphi - a)$$

in which a must have the value above. Hence these expressions should represent $\frac{1}{2}(\lambda_1 - \lambda_3)$ and $\frac{1}{2}(\lambda_2 - \lambda_4)$ in Table VII. The angle of the epoch is about right, but the coefficient of the former is nearly one minute too small and that of the latter a little too great. These slight discrepancies are no doubt, caused by the existence of a small quarter-day tide, which has not been taken into account in (41), from which the preceding expressions have been deduced.

RECAPITULATION OF RESULTS.

35. For the general tidal expressions, (24) and (26), the following constants have been obtained, in which the values of the epochs are for transit C.

In oscillations of mean level, in which $s = 0$,

(83) $$\begin{cases} K_0 = -0.117 \text{ ft.}, & \\ R_1 = 0.504, & a_1 = 0 \\ R_2 = 0.308, & a_2 = -4 \\ R_3 = 0.190, & a_3 = -14 \\ R_4 = 1.08, & a_4 = +74 \\ R_5 = 0.62, & a_5 = -82 \end{cases}$$

In diurnal oscillations, in which $s = 1$, (32),

(84) $$K_1 = -0.58 \text{ ft.}, \qquad a_1 = -19^\circ.7, \qquad B_0 = 1^d\ 22^h\ 34^m$$

In semi-diurnal oscillations, in which $s = 2$,

(85) $$\begin{cases} K_2 = 4.904 \text{ ft.}, & & B_0 = 2^d\ 0^h\ 42^m.25, & \\ R_1 = 0.1388, & a_1 = -10^\circ.5, & B_1 = -22^m.6, & \epsilon_1 = 0^\circ \\ R_2 = 0.1624, & a_2 = +2^\circ.7, & B_2 = 6^m.2, & \epsilon_2 = 45^\circ.6 \\ R_3 = 0.0225, & a_3 = -6^\circ.5, & B_3 = 5^m.3, & \epsilon_3 = 6^\circ \\ R_4 = -0.0077, & a_4 = -65^\circ, & B_4 = -3^m.9, & \epsilon_4 = -73^\circ \\ R_5 = -0.0019, & a_5 = -58^\circ, & B_5 = -0^m.6, & \epsilon_5 = -10^\circ \\ R_6 = -0.0235, & a_6 = -11^\circ, & B_6 = -2^m.5, & \epsilon_6 = -50^\circ \\ R_8 = 0.0054, & a_8 = -45^\circ, & B_8 = 1^m.5, & \epsilon_8 = -25^\circ \\ R_9 = 0.0240, & a_9 = -21^\circ, & B_9 = 3^m.5, & \epsilon_9 = 24^\circ \\ R_{10} = -0.0045, & a_{10} = -2^\circ, & B_{10} = 2^m.0, & \epsilon_{10} = 5^\circ \\ R_{11} = 0.0107, & a_{11} = -9^\circ, & B_{11} = 1^m.0, & \epsilon_{11} = -77^\circ \end{cases}$$

In tertio-diurnal oscillations, in which $s = 3$,

(86) $$K_3 = 0.004 \text{ ft.}$$

In the semi-diurnal tide, depending upon the fourth power of the moon's distance, (36),

(87) $$K'' = .0065, \qquad a'' = -77^\circ, \qquad B_0 = 1^d\ 22^h\ 12^m$$

The absolute values of the coefficients of the tide are $K_s R_i$.

COMPARISONS WITH THE EQUILIBRIUM THEORY.

36. The values of the constants K_s in the equilibrium theory, and also in the dynamic theory in the oscillations of mean level, are given approximately in (31). By comparing these values with

the preceding, it is seen that K_1 and K_3 given by observation are less than the theoretical values, while that of K_2, the mean coefficient of the semi-diurnal tide, is nearly ten times greater. But in applying the equilibrium theory to the real case of nature, it has been usual to determine such constants as make the expressions best represent the observations instead of determining them from theory, and to depend upon the theory for the ratios of the inequalities to these constants. In the equilibrium theory, and also in the dynamic theory in the case of oscillations of mean level, we should have $R_n = P_n$. By comparing the preceding values of R_n with those of P_n (12) it is seen that while P_1 is wanting, $R_1 = .504$, and also that the value of R_2 is greater than that of P_2. The three values of $(R_n - P_n) K_0$ in these three cases give respectively -0.059 ft., -0.020 ft., and $+0.003$ ft. as the coefficients of inequalities in the mean level, belonging respectively to the arguments η_1, η_2, and η_3, for which there are no corresponding inequalities in the disturbing forces. A semi-monthly inequality of mean level, corresponding with the first of the preceding, and with the same sign, though frequently much greater, has usually been found in all tidal discussions.

The parts of the preceding inequalities without any corresponding disturbing forces are, no doubt, the effects of a quarter-day tide, which, with observations of high and low waters only, there are no means of separating from the semi-diurnal tide, and are not inequalities in the true mean level (§ 27); and the preceding inequalities are merely the inequalities in this tide, which varies with the semi-diurnal tide, and the effect of the constant part of this tide is contained in the value of H'_0. Upon this hypothesis, if we assume the existence of a quarter-day tide with a coefficient of about three inches, it would account for these inequalities within the limits of the errors of observation. We have already had indications of the existence of such a tide elsewhere (§ 34). The exact coefficient of such a tide can only be determined from observations made several times during the phase of the tide.

If we compare the values of R_4 (83) with that of P_4 in (12), we see that the latter is a very inconsiderable part of the former, and that the difference corresponds to an annual inequality of mean level with a range of about four inches, for which there is no corresponding disturbing force. The whole of this inequality is given for the middle of each month in the last column of Table VII. The maximum of this inequality occurs in October or November and the minimum in February. Such an inequality has been found at other ports. At Brest it is a little greater, with the maximum and minimum occurring a little later in the year. Dr. Bache found, from the discussion of the tides at Key West, an annual inequality with a range of about nine inches, and with the maximum in September and the minimum in February.

These results should not be regarded as being at variance with the general tidal theory, but merely as being the effects of some circumstances or causes not taken into account in the theory; and these effects are, no doubt, due to the annual changes in the currents of the ocean, produced by annual changes of temperature and of the winds. On account of the influence of the earth's rotation there cannot be an annual change in the velocity or position of the currents of the ocean without a corresponding change generally in the mean level of the ocean at any port. The preceding results are very interesting in connection with this subject. I endeavored to give a full explanation of these inequalities, a few years ago, in the *Proceedings of the American Academy of Arts and Sciences*, Vol. VII, p. 31.

By comparing the values of R_n (85) with those of P_n (18), it is seen that they differ very much, and consequently the equilibrium theory, applied to the Boston tides, gives very erroneous relations between the inequalities and the mean tide. While $R_1 = .1388$, we have $P_n = .4240$, and hence the equilibrium theory would make the semi-monthly inequality in heights more than three times greater than it is. In the same way it is seen that it makes the inequality depending upon the moon's parallax too small, while it makes that depending upon the moon's longitude, or declination, more than four times greater.

37. In the equilibrium theory the lunitidal interval is expressed by $\frac{2\beta_2}{i}$ (22), and the coefficients of the inequalities in the development by Q_n (23). The mean establishment, referred to the nearest transit, should be 0, which does differ much from observation at Boston. But if we compare the preceding value of B_1 with that of Q_1 (23), we see that the equilibrium theory gives nearly two and a half times that of observation for the coefficient of the semi-monthly inequality. For the observed

inequality also of $6^m.2$ depending upon η_2, the equilibrium theory gives none; and throughout the smaller coefficients there are large proportionate differences between the theory and observation.

38. The values of the angles of epoch in the equilibrium theory should be 0 when referred to the nearest transit. The values of a_1 and a_2 (83) both nearly vanish for the transit C occurring two lunar days earlier, and the value of a_3 would vanish for a transit nearly a day and a half earlier. This also applies to the dynamic theory. But it has been shown that these inequalities, except a small part of the second and third, do not depend upon any corresponding term in the disturbing force, but are probably the effects of quarter-day tides, resulting from the circumstance of a shallow sea, and depending upon the magnitude and epoch of the semi-diurnal tide. Hence the values of the angles of the epoch should correspond somewhat with those of the semi-diurnal tide in (85), which they do as nearly as could be expected, since it is impossible to determine the values of the angles accurately for so small inequalities. The preceding comparisons are sufficient to show how inadequate the equilibrium theory is to represent the observed inequalities of the Boston tides.

DETERMINATION OF THE GENERAL CONSTANTS.

39. It is now proposed to determine the constants in the general tidal expressions (25) and (27). These being known, these expressions then give the special constants belonging to each inequality. Among the constants to be determined is the correction of the moon's mass, $\delta\mu$, contained in the expressions of P_1, U_1, and Q_1, (18) and (27). The diurnal tide in the port of Boston being very small, only the coefficient of the principal inequality has been determined from observation, and consequently we have no means of forming conditions enough to determine these general constants belonging to this tide; and they are of no consequence, since the effects depending upon them in this case must be insensible. We can, therefore, only determine these constants for the semi-diurnal tide.

With the values of R_1 (85) belonging to the first three inequalities, and the corresponding values of P_1 and U_1, the first of (25) gives the following conditions:

$$(88)\quad \begin{cases} .1388\,(1+F)=.4305-24.0\,\delta\mu-(.1742-13.2\,\delta\mu)E \\ .1624\,(1+F)=.1521+\ \ 3.6\,\delta\mu+\ .0500\ E \\ .0225\,(1+F)=.0985+\ \ 1.0\,\delta\mu-(.0477-0.5\,\delta\mu)E \end{cases}$$

Also with the values of $M_1=B_1\cos(\epsilon_1-a_1)$, belonging to the same inequalities, the third of (27) gives

$$(89)\quad \begin{cases} -22^m.2=-52^m.5+4034\,\delta\mu+(21^m.75-1210\,\delta\mu)E-0^m.6 \\ \quad 4^m.3=\qquad\qquad\qquad\qquad +(\ 4^m.10+\ 187\,\delta\mu)E-0.3 \\ \quad 5^m.3=-\ \ 2^m.2+\ 148\,\delta\mu+(\ 5^m.16+\ \ 50\,\delta\mu)E-0.1 \end{cases}$$

By giving proper relative weights to these two sets of conditions from the heights and from the times, we can combine them in the determination of the constants, and thus obtain the most probable values which all the conditions give, and get some idea of their probable errors. These six are the only conditions which can be formed having much weight in the determination.

A solution of the first three conditions, (88), depending upon the heights of the tides, gives

$$(90)\qquad \delta\mu=-.000283,\ E=1.408,\ \text{and}\ F=.365$$

With this value of $\delta\mu$, (9) gives for the moon's mass,

$$\mu=.013-.000283=.012717=\frac{1}{78.64}$$

In order to determine the most probable value of the three preceding constants belonging to all of the preceding conditions, we shall multiply the first three by 300 and then substitute the preceding values plus the correction belonging to the new conditions. We thus get

					Residuals. m.
$-1650\,\Delta\mu$	$-51.60\,\Delta E$	$-41.64\,\Delta F$	$=$	0	$.00$
$+1080\,\Delta\mu$	$+15.00\,\Delta E$	$-48.72\,\Delta F$	$=$	0	$+.02$
$+\ 510\,\Delta\mu$	$-14.31\,\Delta E$	$-\ 6.75\,\Delta F$	$=$	0	$-.12$
$+2333\,\Delta\mu$	$+21.75\,\Delta E$		$=$	0.3	$+0.17$
$+\ 262\,\Delta\mu$	$+\ 4.10\,\Delta E$		$=$	-1.2	-1.03
$+\ 218\,\Delta\mu$	$+\ 5.16\,\Delta E$		$=$	0.3	$+0.29$

The solution of these by the method of least squares gives

$$\Delta\,\mu = .000120 \pm .00021,\ \Delta\,E = -.005,\ \text{and}\ \Delta\,F = .001$$

with the residuals given above. The first three residuals divided by 300 and multiplied by 60 inches, the coefficient nearly of the mean tide, give the real residuals in inches, the greatest of which is only .024 inch. The last three are the residuals belonging to the times in minutes. The multiplication of the conditions from the heights by 300 makes the relation between the two kinds of residuals in general about the same as that of the probable errors of the two kinds of observations.

With the preceding corrections we get for the constants belonging to the new set of conditions,

$$(91)\quad \begin{cases} \mu = 0.012717 + (.000120 \pm .00021) = \dfrac{1}{77.9 \pm 1.3} \\ E = 1.408 - .005 = 1.403 \\ F = 0.365 + .001 = 0.366 \end{cases}$$

The preceding residuals show the accuracy with which theory represents the three principal inequalities of the heights and the times. This may be somewhat accidental in this case, and it remains yet to be determined by an application of the theory to other ports, whether it will represent the inequalities of the times with such accuracy that conditions deduced from them should have any weight in the determination of the moon's mass. The preceding probable error, obtained from so few conditions, cannot be relied upon as showing with much certainty the real probable error of such determinations in general.

The preceding value of E for the port of Boston is four or five times as great as it is in most European ports. This extraordinary value, in the first of (25), diminishes the values of R_1 and R_3, and consequently the coefficients of the first and third inequalities, to less than one-third of what they would be by the equilibrium theory, but increases the second inequality, since U_2 is negative, and makes it greater than what the equilibrium theory would require, and even greater than the semi-monthly inequality. In like manner this large value of E, in the third of (27), diminishes the coefficient, and consequently the range, of the first or semi-monthly inequality in the lunitidal intervals, so that at Boston it is only about half as much as in European ports generally, and less than half of what the equilibrium theory requires.

The value of F above, in the first of (25), tends to decrease all the inequalities, and in the first and third is in the same direction with the effect of the term depending upon E; but in the second inequality the effects of the two terms are in contrary directions, but that depending upon E is the greater, and consequently the second inequality is greater than the conditions of a static equilibrium would require. Whether the effect of the term depending upon F is due to friction, as we have supposed, (§ 14), or to some other cause, it is evident that the preceding conditions cannot be satisfied without such a term.

40. In the equilibrium theory both E and F vanish, and in this case the first of either (88) or (89) furnishes a condition for determining the correction of the moon's mass, the former from the heights, and the latter from the times. It is well known that this theory, even in European ports, where the deviation from the relations of the equilibrium theory is comparatively small, gives very unreliable determinations of the moon's mass; but in the port of Boston it would give a mass more than double the true mass, as may be seen from a mere inspection of the conditions in this case. The preceding conditions are based upon the hypothesis of a small correction only, and consequently fail in this case, except that they indicate that it must be very large.

In the equilibrium theory only one condition is necessary for determining the moon's mass, which can be based upon the first and principal inequality. Where the term depending upon E has a sensible effect, a second condition is necessary, which may depend either upon the second or third inequalities. Laplace, in his last tidal investigations in the fifth volume of the *Mécanique Celeste*, used the first and third inequalities. Airy, in the discussion of the tides of Ireland, formed conditions from the first and second inequalities, but obtained a mass very much too great. When the terms depending upon F in the preceding conditions have a sensible value, it is readily seen that these two sets of conditions must give very different results, and that the conditions based upon the first and third inequalities must be much better than those based upon the first and

second, since the effects of the two terms depending upon E and F are in the same direction in the former conditions, and somewhat in the same proportion, while in the latter they are in contrary directions.

When the terms depending upon F are sensible, there are three quantities to be determined, and consequently three conditions are necessary, and two of these conditions, if the heights alone are used, have to depend upon the small parallactic and declination inequalities belonging to the moon. Where circumstances are such as to make the terms depending upon E and F small, as at Brest, the conditions are sufficient to determine them with adequate precision to get a pretty accurate determination of the moon's mass; but in the case of the Boston tides these become terms of a first order, which, in a great measure, destroy the first and third inequalities, upon which the determination mainly depends, so that the problem becomes nearly indeterminate, and the conditions are not sufficient to give a reliable determination of the moon's mass; for the small semi-monthly inequality observed is not wholly due to the solar tide, which is a kind of base in the determination, but a considerable part of it belongs to that term in the moon's parallax depending upon the argument of variation, and which gives no advantage in forming the conditions.

By the preceding method, in which conditions from the times are taken in, which our tidal expressions enable us to do, the great weight of the determination which rests upon the small declination inequality, which, in the case of the Boston tides, is reduced to 1.3 inches, is thrown upon the principal semi-monthly inequality of the lunitidal intervals, which is $22^m.6$, and which can be observed with much greater accuracy, proportionately, than 1.3 inches in the heights. The two other conditions from the times also give some little additional weight to the determination. The accuracy of the determination, of course, depends very much upon the accuracy of the tidal expressions, and the probable error may be greater than that which we have obtained from so few conditions, but still I think the determination is entitled to considerable weight. But it is very evident, from what has been stated, that the Boston tides are not at all favorable for an accurate determination of the moon's mass, and that the same magnitude of errors in theory or observation makes the probable error of the determination several times greater than in the case of tides, as those of Brest, in which the magnitudes of the inequalities differ but little from what the equilibrium theory would give.

COMPARISONS WITH THE DYNAMIC THEORY.

41. In the oscillations of the first kind, which are oscillations of long period, the terms depending upon E, F, and G vanish, and the dynamic corresponds with the equilibrium theory, with which comparisons have already been made. The diurnal tides of Boston being very small, only the constants of the principal term depending upon the moon's longitude have been determined from the observations; and, as it requires at least two conditions to determine the constants in the expressions (25) and (27) for each kind of oscillation, we have no means of making any comparisons of results obtained from the observations with those given by these expressions. The constants E and F having been determined for the semi-diurnal tide, (90), the first of (25) should give the value of R_i for each of the inequalities of which we know the value of P_i; and K_2 being known, we then have $K_2 R_i$, the coefficients of the inequalities. The third of (27) should likewise give $M_i = B_i \cos (E_i - a_i)$. Three of the values of R_i and M_i, obtained from observation, belonging to the three principal inequalities, have been used in the six conditions by which the constants have been determined, and, from the smallness of the residuals, it is seen that, so far as these three inequalities are concerned, the observations are well represented by theory.

The values of τ, obtained from (28), with the angles of epoch a_i, should all be equal, according to theory, taken in terms of a first order only. But, we see from (64), (68), and (71), these values differ considerably at Boston. Neglected terms of a second order, which are very large at Boston, are, no doubt, sensible in this case. It is difficult, also, to obtain the angles of epoch of small inequalities of long period with much accuracy from the observations, but in this case the differences seem to be rather great to be attributed to errors of observation. The other inequalities are too small to give a reliable value of τ.

The values of the angles of epoch E_i, in the inequalities of the intervals, should be given by the second of (27), but no value for F' in the expression of N_i can be obtained which will represent them

accurately, and there are evidently some neglected sensible terms which affect this expression. But these angles depend upon very small quantities, since the coefficients are mostly very small, and consequently a very small effect throws them very much out.

In the fourth and fifth inequalities of the heights depending upon the sun's parallax and declination, the observed inequalities are both quite small, less than a half-inch, as theory requires; but here also there are some disturbing influences not represented in the theory, for the coefficients have the contrary sign, and the angles of the epoch, which in this case should be sensibly 0, since $D_t \eta_4$ and $D_t \eta_5$ are insensible in the expression (25), are quite large.

These disturbing effects belong mostly to the fourth inequality having an annual period, and are, no doubt, due in part to the varying effects of friction, caused by annual variations in the velocities and positions of ocean-currents, as the Gulf Stream; for such variations, depending upon the changes of the seasons and of temperature, must have an annual period. We have seen that in the oscillations of mean level also there is a very considerable annual inequality not indicated by theory, which we have supposed to be due to influences of the same kind, (§ 36). Now, any amount of change of mean level, from whatever cause, must also produce a slight corresponding effect upon the range of the tidal oscillations and also upon the time, which, in very shallow seas and harbors, may be quite sensible to observation. According to theory, the value of B_4 (85) should be 0; hence we have an annual inequality in the times with a coefficient of four minutes, which must be due to the same causes, as the angle of the epoch, corresponding very nearly with that in the inequality of the heights, seems also to indicate. These seeming deviations from theory are merely the effects of slight disturbing influences not taken into account in the theory, and should be regarded as very important in the investigation of the subject of tidal friction in connection with ocean-currents varying with the seasons.

We come now to the sixth inequality, depending upon the moon's node. In this case U_6 in the first of (25) being sensibly nothing, we should have $(1+F)R_i = P_i$, or substituting the value of P_6 (18), and the observed value of R_6 (85), we should have $.0235\ (1+F) = .0375$. This gives the value of F, as deduced from this small inequality alone, equal to nearly .6, which is larger than the value before obtained from conditions from all the principal inequalities. With the value .401 before obtained, the preceding equation gives $R_6 = -.0268$, and consequently the tidal coefficient given by the tidal expression is too great by $-(.0268 - .0235) \times 60$ inches, or about one-fifth of an inch. If $F = 0$, then the observed value of R_6 should be equal to P_6, the value of R_6 belonging to static equilibrium. But the difference is nearly an inch, which is entirely too great to be attributed to errors of observation; and hence the comparison of observation with theory, in the case of this small inequality alone, shows that F must have a sensible value, and that all the terms depending upon it which have never before been taken into account in any tidal theory, must, in the port of Boston at least, have very sensible values.

The value of $B_6 = -2^{m}.5$ (85) in this case must depend upon F' in the expression of N_6 (27), since all the other terms in the expression vanish in this case. This indicates that F should have a positive value, as is also required in the first inequality. The effect of terms depending upon F^1 then is to cause the lunitidal intervals of larger tides to be a little greater than those of smaller ones, and consequently neglecting terms of a third order, to introduce small inequalities into the intervals proportional to the inequalities in the heights.

All the remaining coefficients of the inequalities are quite small and unimportant, and, in the comparison of them with the tidal expressions as here given, there is not a very nice agreement, some of the residuals being nearly an inch. But the correct tidal expressions for these inequalities of a second order depend upon so much development that the more simple expressions, as given in the preceding pages, in which many terms are necessarily neglected, cannot be expected to give accurately these small inequalities in this case on account of the neglected terms, which, although in most cases insensible in the Boston tides, on account of the large value of E, must be quite sensible. The coefficients of the remaining inequalities in the times, as given by observation, agree very well with those given by the tidal expressions, none of the residuals being more than $0^{m}.5$.

42. All solutions of the tidal problem, extended to the cases of different and varying motions of the disturbing bodies in right ascension assume, as Laplace substantially expresses it, that if the tidal coefficient changes with any change of the motion of the disturbing body in right ascen-

sion, the corresponding changes when small may be regarded as exactly proportional. This is equivalent to supposing that in the development of the tidal coefficient K, which is a function of i, by Taylor's theorem, only the first term depending upon δi, of which the coefficient is D_i K or E, is sensible, and that all the others, depending upon the square and higher powers of δi, may be neglected. This is, no doubt, true of Brest, and of most European ports, but we are hardly safe in assuming that it is strictly true in the case of the Boston tides; for we have seen that the effect of the first term, that depending upon E, is a quantity of the first order of the inequalities, and in the case of the semi-monthly inequality amounts to more than a fourth part of the whole tidal coefficient, and hence it can hardly be supposed that the second term depending upon $(\delta i)^2$ is entirely insensible. If such terms are sensible they must cause slight deviations of observation from theory, and also affect the determination of the moon's mass. The smallness of the residuals, however, do not indicate that the effect of such terms, if at all sensible, can be of much consequence.

PREDICTION FORMULÆ AND TABLES.

43. With the preceding tidal expressions the heights and times of the tides may be computed for any given time; but although these expressions are in a form most suitable for the discussion of the tide observations and comparisons with theory, and for the study and investigation of the tidal theory, yet on account of the great number of arguments which would have to be used, and number of terms taken in, resulting from the developments, the whole result can be put into a more suitable form for prediction, containing but few arguments. For this purpose we shall determine from the constants belonging to the resultant tides of the moon and sun, which have been obtained directly from comparisons of observation with the tidal expressions, certain constants belonging to the lunar and solar tides considered separately, and then combine these separate tides into a form of expression similar to that of the resultant expression of the potentials of the disturbing forces of the moon and sun, (5) and (6).

By neglecting the effect of friction depending upon F, which decreases the larger tides a little more in proportion than the smaller ones, the first of (25) may be used, with the value of E which we have obtained, in determining the relative magnitudes of the lunar and solar tides. In this case the quantity corresponding to U_i is $D_t\,\eta_1 = .426$, twice the difference of the velocities of the moon and sun in right ascension. If we therefore put e' = the ratio between the solar and lunar tide, since e (8) is the ratio between the solar and lunar disturbing forces, we shall have

$$e' = e(1 - .426\,\mathrm{E}) = 0.180 \tag{92}$$

using the values of e, $\delta\mu$, and E in (10) and (90). Hence the solar tide is decreased in the ratio of 1 to 1—.426 E, or of 1 to .401, in consequence of the sun's having a slower motion in right ascension than the moon.

44. If we now consider the lunar tide alone, omitting that part of the effect of friction which depends upon F, since in this case the inequalities in the disturbing force depend upon the moon's parallax and declination only, we shall have in (17)

$$\Sigma_i\,\mathrm{P}_i \cos \eta_i = \mathrm{C}\left(1 + \frac{\delta p}{\mathrm{p}}\right)^3 (1 - \sin^2 \mathrm{v}) \tag{93}$$

in which C is a constant and p is the mean parallax, δp is the excess of the parallax above the mean parallax, and v is the moon's declination, as heretofore defined. In this case the values of P_i in the first member, and the corresponding values of U_i, are different from those already given in the case of the resultants of the potentials, and are found to be

$$\left\{\begin{aligned} \mathrm{P}_1 &= .0250, & U_1 &= -.0073 \\ \mathrm{P}_2 &= .1638, & U_2 &= -.0500 \\ \mathrm{P}_3 &= .0860, & U_3 &= .0397 \end{aligned}\right. \tag{94}$$

omitting the terms depending upon the moon's node and other small secondary terms. With these values the first of (25) gives, omitting F,

$$\left\{\begin{aligned} \mathrm{R}_2 &= .1638 + .0503 \times 1.408 = .2342 \\ \mathrm{R}_3 &= .0860 - .0397 \times 1.408 = .0302 \end{aligned}\right. \tag{95}$$

Hence R_2, and consequently the coefficient of the corresponding tidal inequality, is increased in the ratio of .1638 to .2342, or of 1 to 1.429, in consequence of the moon's excess of motion at perigee over its mean motion. Also R_3, and the corresponding tidal coefficient, are decreased in the ratio of .0860 to .0302, or of 1 to .351, in consequence of the moon's decreased motion in right ascension when on the equator, on account of the obliquity of the ecliptic. It should be understood that the preceding ratios are not the ratios of increase or decrease compared with the whole tidal coefficient, but the ratio of increase or decrease of the whole tidal coefficient compared with the corresponding inequality having the same argument. The ratio of increase of the mean tidal coefficient at the maximum is, in the former case, $1+.0500\times1.408=1.070$, and of decrease in the latter, $1-.0397\times1.408=.944$.

Since the increase of the moon's angular motion is proportional to the increase of the parallax, for any increase of the parallax above the mean parallax the ratio of increase of the tidal coefficient of the inequality or variation is 1.429 times greater. If we also compare the moon's motion in right ascension with that motion when on the equator, the increase of motion may be assumed to be as $\sin^2 v$. This is not strictly true, especially with regard to the effects depending upon the moon's node, but the error, as applied to this small inequality, is insensible even in the Boston tides. For any decrease, therefore, of the coefficient of the disturbing force due to declination, the ratio of decrease of the corresponding tidal coefficient is .351.

What has been stated with regard to the lunar tide is also true of the solar tide, except that the relative ratios of increase or of decrease are different.

45. If we therefore put, supposing $F=0$,

M=the value of A_2, (33), in the case of the moon,
S=its value in the case of the sun,

we shall have, without sensible error,

$$\text{(96)}\qquad \begin{cases} M = K\left(1+m\,\dfrac{\delta p}{p}\right)^3(1-n\sin^2 v) \\ S=e'K\left(1+m'\dfrac{\delta p'}{p'}\right)^3(1-n'\sin^2 v') \end{cases}$$

in which the accented letters denote the same with regard to the sun which the same letters without an accent do with regard to the moon, and in which p and v must be taken at the times τ_2 and τ_3 earlier. In the case of the moon we have found $m=1.429$, $n=.351$. On account of the sun's slow motion in right ascension, m' and n' may be put equal to unity without sensible error.

If we combine the separate expressions of the lunar and solar tides, as given by (33), as in the case of the potentials of the disturbing forces (5), we get for the combined semi-diurnal tides,

$$\text{(97)}\qquad Y_2=\sqrt{M^2+S^2+2MS\cos(\gamma_1-\alpha_1)}\cos(2\rho-l-\beta')=Q\cos(2\rho-l-\beta')$$

in which

$$\text{(98)}\qquad \tan\beta'=-\frac{S\sin(\gamma_1-\alpha_1)}{M+S\cos(\gamma_1-\alpha_1)}$$

These expressions do not include certain small corrections belonging to inequalities of a second order due to changes of the moon's motion in right ascension, but these are very small and of no practical importance.

The lunitidal interval in the preceding expression, in solar time, is

$$\text{(99)}\qquad L=1.035\frac{\beta'+l}{D_t(2\rho-l-\beta')}$$

and is equivalent to (27), putting $\Sigma_i\,Q_i=1.035\,\beta'$, and using the preceding values of P_i, belonging to the moon only, in the rest of the expression.

The great advantage of the preceding forms of expressions is that we dispense with all development in the computation of the tidal coefficient, and the trouble of taking into account a very great number of small terms, in the development with arguments depending upon the sums and differences of the principal arguments, and have as arguments merely the time of the moon's transit and the parallaxes and declinations of the moon and sun. The same is true also of the part of the lunitidal

interval depending upon β', which is the principal part, the remainder being generally quite small, so that it need be applied as a correction only to a few of the principal terms.

46. If we develop the preceding expressions, as in the case of the potential of the disturbing force, substituting for p, v, p', and v', their expressions depending upon the angles η_1, we should obtain expressions of the resultant of the lunar and solar tides similar to those in the preceding pages, (25) and (27), obtained from the resultant of lunar and solar disturbing forces, of which the constants should be equivalent, and the coefficients of the inequalities of the latter, divided by $(1+F)$, should be equal to the corresponding ones in the former.

In the comparison of the constants we get

$$\sqrt{1+e'^2}\,.956\,K=K_2 \tag{100}$$

The preceding must be used as a condition to determine K in (96).

In the comparison of the coefficients of the semi-monthly inequalities in the development of (97) and (98), using the value of e' (92) with those given by observation and by (25) and (27), it is found that the coefficient of the inequality in heights is too great by $0^m.7$, and that of the lunitidal intervals is too small by $1^m.5$. The theory with regard to this last expression and development seems to be in error by these amounts. But as our object here is merely to get the most convenient expression which will represent the observations with sufficient accuracy for practical purposes, this can be obtained by changing a little the constants as obtained from the former conditions. If we take

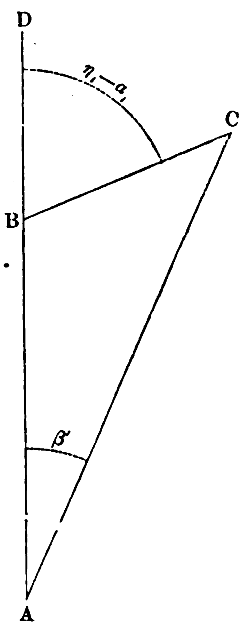
$$e'=.205, \qquad m=1.530, \qquad n=.410, \qquad F=.500 \tag{101}$$

with these values in (96), (97) will give the principal inequalities in the heights, except the effects of F, within $0^m.2$, and all the others with about the same accuracy as (25), and (97) will give such a value of β' as, substituted in (99), will give the coefficients of the intervals within $0^m.5$, except the few discrepancies already mentioned in the comparisons with the expression of (27). The preceding constants, however, in this case do not quite have the relations to one another required by theory in the other developments.

With the preceding value of e', and the value of K_2 (60), (100) gives for the constant in (96),

$$K=5.004 \text{ feet.} \tag{102}$$

47. Having obtained M and S from (96), the coefficient of the tide Q and the value of β' in (97) and (98) are readily obtained by construction as follows:



Take A B equal to M, and B C equal to S, making an angle with A B, produced to D, equal to η_1-a_1, which is twice $\psi-\psi'$ at a time τ_1, previous to the time of high or low water, and then join A C. The latter is Q (97), or the coefficient of the tide, neglecting the effect of F. The angle B A C also is the value of β'. Of course the same are readily obtained by a trigonometrical calculation. One-half β', reduced to time and increased by $\frac{1}{30}$th, is the part of the lunitidal interval in solar time depending upon β'.

The values of M and S (96) contain only the parallaxes and declinations of the moon and sun as arguments, and very simple and convenient tables may be constructed giving their values for any given arguments; and then by a very simple construction, or trigonometrical calculation, we get the coefficient of the tide and the principal part of the interval, and thus take in completely all the numerous terms arising from any developed form of expression. These terms do not consist only of the terms corresponding to the terms given in the development of the disturbing forces in (12) and (18), but a great many others of the same order as many given there. The coefficient of the tide thus obtained must be diminished by one-third of the inequality from the mean tide for the effect of friction depending upon F, which is the same as dividing the inequality by $(1+F)$.

It now remains to determine the part of L depending upon l in (99), which is the lunitidal interval of the lunar tide. The constant of this is B_0 determined by

observation (56), and the inequalities are determined by (27) omitting Q, and using the preceding values of P_i (94) belonging to the lunar tide only. This gives for the lunar part,

$$(103) \qquad M_1=1^m.7, \quad M_2=5^m.8, \quad M_3=6^m.1, \text{ \&c.}$$

The first of these belongs to the small term in the moon's parallax depending upon variation, and is added to the value of the first inequality depending upon β', which is $-24^m.2$, to give the whole semi-monthly inequality $-22^m.5$. The second is the whole value of B_2, there being no part depending upon β'. The part of the third inequality depending upon β' is $-1^m.0$, and hence the whole value of B_3 is $5^m.1$.

48. For the sake of convenience in computation we can put in (27), in the case of the lunar tide,

$$(104) \qquad \Sigma_i M_i \sin \eta_i = C\, D_t\, p + C' \sin 2\, v\, D_t\, v$$

in which

$D_t\, p$ = the hourly change of parallax in seconds,

$D_t\, v$ = the change of declination in seconds for one minute of time.

For the principal term of parallax of which the coefficient is $186''.5$; the hourly change is $1''.79 \sin \eta_2$; also, the change of $\sin 2\, v\, D_t\, v$ in seconds for one minute of time is $5''.6 \sin \eta_3$. Hence, the constants in the preceding expression are determined by the following conditions, using $5^m.3$ given by observation for the value of M_i instead of $5^m.8$ given by theory, (103):

$$(105) \qquad \begin{cases} 1.79\ C = 5^m.3 \\ 5.6\ \ C' = 6^m.1 \end{cases}$$

These conditions give $C=3$ very nearly, and $C'=1.1$. With these constants, (104), using seconds of arc as minutes of time, gives the sum of all the terms depending upon $D_t\, \eta_i$, independently of any developed expression, directly from the hourly differences of parallax, and the differences of declination for one minute, taken from the Nautical Almanac.

In addition to the preceding we have the terms $\Sigma_i N_i \cos \eta_i$ (27) depending upon friction and other disturbing causes, of which it is only necessary to take account of the following, in which the coefficients given by observation are used, being reduced from transit D to the transit occurring at the time τ before the time of the tide, using the correction (34) for changing from one transit to another:

$$\begin{aligned} N_1 \cos \eta_1 &= \ \ 4^m.0 \cos \eta_1 \\ N_2 \cos \eta_2 &= -6^m.0 \cos \eta_2 \\ N_3 \cos \eta_3 &= \ \ 1^m.5 \cos \eta_3 \\ N_4 \cos \eta_4 &= \ \ 4^m.0 \cos \eta_4 \\ N_6 \cos \eta_6 &= \ \ 2^m.5 \cos \eta_6 \end{aligned}$$

All the other terms of this form are included in the terms depending upon β' in (99).

The first three and the last of these terms are embraced in Table III, the fourth one in Table II.

To both the times and heights must be added, also, the effect of the term depending upon the fourth power of the moon's distance, given in (69) and (70). These inequalities are given in the last two columns of Table IV.

The summation of the preceding effects gives the values of A_2, (24) or (33), and L_2, (26).

The value of H_0, the height of mean level, neglecting the very small inequalities given by observation as of no practical importance, is given in Table III.

The value of A_2 added to H_0, gives the height of high water, and, subtracted from H_0, gives that of low water.

To both the heights and times must then be added the effects of the lunar and solar diurnal tides to obtain the complete height and time of the tide. The effects of the lunar tide upon both the height and time of the tide are contained in Table IV, and those of the solar diurnal tide in Tables VIII, IX, X, and XI.

COMPUTATION OF A TIDAL EPHEMERIS.

49. The method of using the preceding formulæ and results in the computation of a tidal ephemeris is most conveniently explained by a reference to the example given at the end:

A is the mean time of the moon's upper transit over the meridian preceding the Washington meridian 2.4 hours, and is obtained from page 332 of the American Ephemeris by interpolation by means of the hourly differences.

a is the equation of time to be subtracted from mean time.

B contains the hours and minutes of the apparent time of the moon's transit over the meridian above stated.

C is the moon's horizontal parallax for a time 18 hours before the time of the Washington transit, or about 6 hours after the preceding upper transit, taken from page 339 of the American Ephemeris, by interpolation by means of the hourly differences.

c is the corresponding hourly difference.

D is the moon's declination 7 hours preceding the time of Washington transit, or 2 hours preceding the time of the Greenwich transit, taken from page 6 of the American Ephemeris.

d is the corresponding hourly difference of declination.

L′ is the part of L (99) depending upon β', or upon the solar tide, plus a constant of 30 minutes.

The part independent of the constant, and also Q, can be readily obtained, with sufficient accuracy for practical purposes, by construction or by trigonometry, as has been explained in (§47). But the method by trigonometry does not answer well near the times of the conjunctions or quadratures, where the angles are very small, unless these angles are determined with great accuracy. If L′ and Q are determined by computation it is best to compute Q and β', (97) and (98), directly from the expressions, as in the last part of the example at the end, in which

M is taken from Table I, with the arguments C and D, and

S from Table II, with the date as the argument.

Log sin 2 B and log cos 2 B are taken from Table VII, which is so arranged, with the sine and cosine adjacent to each other, that they can be taken out at the same time, using B instead of 2 B as an argument. The remaining steps in the example, to obtain tan β', need no explanation. With tan β' as an argument, the variable part of L′ is taken from Table VI, to which the constant, 30 minutes, is added to make all the values positive.

e is equal to three times *c* with the sign changed, calling seconds of arc minutes of time, plus a constant of 10 minutes.

f is taken from Table V, with D and *d* as arguments, a constant of 10 minutes being also added.

g is taken from Table III, with the time of transit, B, as an argument.

h is taken from the same, with the parallax, C, as an argument.

i is also taken from the same, with the declination, D, as an argument.

j is taken from the last part of Table IV, using the declination, D, one day in advance, as taken out above.

B_0 is taken from Table II, with the date as the argument, the day and hours not being written in the example, but borne in mind.

$E = A + L' + e + f + g + h + i + j + B_0$

The value of A being taken from the ephemeris in astronomical time, the constant, B_0, in the table has been increased 12 hours in order to give E in civil time. When the *apparent* time of high water is required, B should be used instead of A in the preceding expression of E.

Δ^1 and Δ^2 are the first and second differences of E belonging to the upper transits, used as a check, and also for interpolating the intermediate numbers belonging to the lower transits. The minutes only of Δ^1 are written in the example, the 24 hours being understood. The intermediate numbers, in smaller type, are $\frac{1}{2}\Delta^1$ and $\frac{1}{8}\Delta^2$, used in the interpolation.

δ^1 are the differences after interpolation, used as a check, and also in interpolating to low water, the 12 hours understood not being written.

k is taken from the last part of Table IV, with D as an argument taken one day in advance.

l is the effect of the solar diurnal tide upon the time of high water, taken from Table VIII, with B and the day of the year as arguments.

$m = k + l$ is the effect of the whole diurnal tide upon the time of high water. The values belonging to the lower transit are readily obtained by interpolation, and must be used with a contrary sign.

$t.h.w=\mathrm{E}+m$ are the times of high water; the days and hours, being the same as in E, are not written.

Q, the coefficient of the semi-diurnal tide, independent of the effect of F, is obtained either by construction, as has been explained, or from log Q in the latter part of the example, when obtained by computation. The different steps in the example, by which log Q is obtained, need no explanation.

$n=\mathrm{Q}-4.90$ ft.; that is, it is the excess of Q above its mean value. One-third of this subtracted from Q gives $\mathrm{A}_2=4.90+\frac{\mathrm{Q}-4.90}{1+\mathrm{F}}$, or the coefficient of the semi-diurnal tide as affected by F.

Δ^1, Δ^2 are the first and second differences of A_2, used as a check, and also in interpolating for the lower transits.

δ^1 are the first differences of A_2 after interpolation, used as a check, and for interpolating to low water.

$\mathrm{H}_0+\mathrm{A}_2$, in which H_0 is taken from Table II, with the day of the year as an argument, is the height of high water of the semi-diurnal tide.

p is taken from the first part of Table IV, with the declination, D, one day in advance, and is the effect of the lunar diurnal tide upon the height of high water.

q is taken from Table X, with B and the day of the year as arguments, and is the effect of the solar diurnal tide upon the height of high water above the zero of the tide-gauge.

$r=p+q$ is the effect of the whole diurnal tide upon the height of high water. The values of r for the lower transits are readily obtained by interpolation, and must be used with the contrary sign.

$h.h.w=\mathrm{H}_0+\mathrm{A}_2+r$ is the height of high water.

E' is obtained from E by interpolation to the time of low water by means of δ^1, using only the first differences.

k' is taken from the first part of Table IV for low water, using the argument D one day in advance.

l' is taken from Table IX, with the arguments B and the day of the year.

$m'=k'+l'$ is the whole effect of the diurnal tide upon the times of low water. The values of m for lower transits are obtained by interpolation and must be used with the contrary sign.

$t.l.w=\mathrm{E}+m'$ are the times of low water, the days and hours being the same as in E'.

A'_2 is obtained from A_2 by interpolation to the time of low water.

$\mathrm{H}_0-\mathrm{A}'_2$ is the height of the low water of the semi-diurnal tide.

p' is taken from the first part of Table IV for low water, using the argument D one day in advance, and is the effect of the lunar diurnal tide upon the height of low water.

q' is taken from Table XII, with B and the day of the year as arguments, and is the effect of the solar diurnal tide upon the height of low water.

$r'=p'+q'$ is the effect of the whole diurnal tide upon the height of low water. The values of r for lower transits are obtained by interpolation, and must have the contrary sign.

$h.l.w=\mathrm{H}_0-\mathrm{A}'_2+r$ is the height of low water.

CONCLUSION.

50. In the preceding discussion all the results have been brought out which can be of much interest to any one in any theoretical tidal investigations; and much attention has been given to the arranging and presenting of the whole matter in as systematic and concise a manner as possible, and with a convenient and appropriate notation. These results must be found to be the more interesting to investigators on account of the great peculiarities due to local circumstances which make them differ so much in many respects from the results obtained in most of European ports. A comparison of these results has also been made with both the equilibrium and the dynamical theories of the tides, so far as it could be done, where it is neither convenient nor proper to enter very thoroughly into the discussion of tidal theories; and the great defects of the equilibrium theory have been shown, and also various discrepancies of a small order between the results and

our tidal expressions based upon the dynamic theory have been pointed out. These are due, no doubt, mostly to friction in connection with ocean currents, and to the peculiarities arising from local circumstances, which cause many small terms, which are necessarily neglected in the tidal expressions, and which in most ports are insensible, to be quite large in the Boston tides.

Much study and care has also been given to the formation, from these results, of the mos convenient formulæ possible for the prediction of the times and heights of the tides, and by means of various auxiliary tables, to render the labor of their computation as small as possible. An example has also been given of the most convenient method of carrying out the computations, from which it may be seen that they can be made with great facility and also with great accuracy.

In the comparison of individual tides as computed with the formulæ and tables, with observation, considerable discrepancies are often found in both the times and the heights, as is to be expected, on account of the many abnormal disturbances arising from the changes in the forces and directions of the wind and in the barometric pressure, and these discrepancies are especially found during the winter and spring, when these changes are the greatest; but still it is thought that the computation gives very accurately the true normal tide. From the discussion of these residuals with reference to the winds and the barometric pressure, some interesting results may yet be obtained with regard to their effects upon the tides. The computation of the tides for a portion of the series is now being made for this purpose, the results of which must be the subject of a future report.

In the prosecution of the preceding discussions I have to acknowledge the receipt of much valuable and very satisfactory aid from the Misses Lane, in the Coast Survey service.

Very respectfully, yours,

WM. FERREL.

Professor BENJAMIN PEIRCE,
Superintendent United States Coast Survey.

NOTE.—The following tables are added by way of appendix to the preceding discussion of the Boston tides. They were prepared by Mr. Ferrel, and show the application of the theory.

APPENDIX TO THE DISCUSSION OF THE BOSTON TIDES, BY MR. W. FERREL.

TABLE I—*Showing the value of* M *for every* 10″ *of the moon's parallax, and for every* 2° *of its declination.*

Moon's parallax.		Moon's declination.														
		0 . . . 2°	4°	6°	8°	10°	12°	14°	16°	18°	20°	22°	24°	26°	28°	30°
′	″	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
54	0	3.88	3.87	3.86	3.85	3.83	3.81	3.79	3.76	3.73	3.70	3.66	3.62	3.58	3.53	3.48
	10	3.94	3.93	3.92	3.90	3.88	3.86	3.84	3.81	3.78	3.75	3.71	3.67	3.63	3.58	3.53
	20	4.00	3.99	3.98	3.96	3.94	3.92	3.90	3.87	3.84	3.81	3.77	3.73	3.69	3.64	3.58
	30	4.06	4.05	4.04	4.02	4.00	3.98	3.96	3.93	3.90	3.86	3.82	3.78	3.74	3.69	3.64
	40	4.12	4.11	4.10	4.08	4.06	4.04	4.02	3.99	3.96	3.91	3.87	3.83	3.79	3.74	3.69
	50	4.18	4.17	4.16	4.14	4.12	4.10	4.08	4.05	4.01	3.97	3.93	3.89	3.85	3.80	3.74
55	0	4.24	4.23	4.22	4.20	4.17	4.15	4.13	4.10	4.07	4.03	3.99	3.95	3.90	3.85	3.79
	10	4.30	4.29	4.28	4.26	4.23	4.21	4.19	4.16	4.13	4.09	4.05	4.00	3.95	3.90	3.85
	20	4.36	4.35	4.34	4.32	4.29	4.27	4.25	4.22	4.18	4.14	4.10	4.05	4.00	3.95	3.90
	30	4.42	4.41	4.40	4.38	4.36	4.34	4.31	4.28	4.24	4.20	4.16	4.11	4.06	4.01	3.96
	40	4.48	4.47	4.46	4.44	4.42	4.40	4.37	4.34	4.30	4.26	4.22	4.17	4.12	4.07	4.01
	50	4.54	4.53	4.52	4.50	4.48	4.46	4.43	4.40	4.36	4.32	4.28	4.23	4.17	4.12	4.06
56	0	4.60	4.59	4.58	4.56	4.54	4.52	4.49	4.46	4.42	4.37	4.32	4.27	4.22	4.17	4.12
	10	4.67	4.66	4.65	4.63	4.60	4.58	4.55	4.51	4.47	4.43	4.38	4.33	4.28	4.23	4.17
	20	4.74	4.73	4.72	4.70	4.67	4.65	4.62	4.58	4.54	4.50	4.45	4.40	4.35	4.29	4.23
	30	4.81	4.80	4.79	4.77	4.74	4.72	4.69	4.65	4.61	4.56	4.51	4.46	4.41	4.35	4.29
	40	4.87	4.86	4.85	4.83	4.81	4.79	4.76	4.72	4.67	4.62	4.57	4.52	4.47	4.41	4.35
	50	4.93	4.92	4.91	4.89	4.87	4.85	4.82	4.78	4.73	4.68	4.63	4.58	4.53	4.47	4.41
57	0	5.00	4.99	4.98	4.96	4.94	4.92	4.89	4.85	4.80	4.75	4.70	4.65	4.59	4.53	4.47
	10	5.07	5.06	5.05	5.03	5.00	4.98	4.95	4.91	4.86	4.81	4.76	4.71	4.66	4.60	4.54
	20	5.14	5.13	5.12	5.10	5.07	5.05	5.02	4.98	4.93	4.87	4.82	4.77	4.72	4.66	4.60
	30	5.21	5.20	5.19	5.17	5.14	5.12	5.09	5.05	5.00	4.94	4.89	4.84	4.79	4.73	4.67
	40	5.28	5.27	5.26	5.24	5.21	5.19	5.16	5.11	5.06	5.01	4.96	4.91	4.85	4.79	4.73
	50	5.35	5.34	5.33	5.30	5.27	5.25	5.22	5.18	5.13	5.08	5.03	4.97	4.91	4.85	4.79
58	0	5.41	5.40	5.39	5.37	5.34	5.32	5.29	5.25	5.20	5.14	5.09	5.03	4.97	4.91	4.85
	10	5.48	5.47	5.46	5.44	5.41	5.39	5.36	5.32	5.27	5.21	5.16	5.11	5.05	4.98	4.91
	20	5.55	5.54	5.53	5.51	5.49	5.47	5.44	5.40	5.34	5.28	5.23	5.17	5.11	5.05	4.98
	30	5.63	5.62	5.61	5.59	5.56	5.54	5.51	5.46	5.41	5.35	5.29	5.23	5.17	5.11	5.04
	40	5.70	5.69	5.68	5.67	5.64	5.61	5.57	5.52	5.47	5.42	5.37	5.31	5.24	5.17	5.10
	50	5.77	5.76	5.75	5.73	5.71	5.68	5.65	5.61	5.55	5.49	5.43	5.37	5.31	5.24	5.17
59	0	5.85	5.84	5.83	5.81	5.78	5.75	5.72	5.68	5.62	5.56	5.50	5.44	5.37	5.30	5.23
	10	5.93	5.92	5.90	5.88	5.85	5.82	5.78	5.73	5.68	5.63	5.57	5.51	5.44	5.37	5.30
	20	6.00	5.99	5.97	5.95	5.92	5.89	5.85	5.81	5.76	5.71	5.65	5.58	5.51	5.44	5.37
	30	6.08	6.07	6.06	6.03	6.00	5.97	5.93	5.89	5.84	5.78	5.72	5.65	5.58	5.51	5.43
	40	6.15	6.14	6.13	6.10	6.07	6.04	6.00	5.95	5.90	5.85	5.79	5.72	5.65	5.58	5.50
	50	6.23	6.22	6.20	6.17	6.14	6.11	6.07	6.02	5.97	5.92	5.86	5.79	5.72	5.64	5.56
60	0	6.30	6.29	6.28	6.25	6.22	6.19	6.15	6.10	6.05	5.99	5.92	5.85	5.78	5.71	5.63
	10	6.38	6.37	6.36	6.33	6.30	6.27	6.23	6.18	6.12	6.06	5.99	5.92	5.85	5.78	5.70
	20	6.46	6.45	6.43	6.41	6.38	6.35	6.31	6.26	6.20	6.14	6.07	6.00	5.93	5.85	5.77
	30	6.54	6.53	6.51	6.49	6.46	6.43	6.39	6.34	6.28	6.22	6.15	6.08	6.00	5.92	5.84
	40	6.62	6.61	6.60	6.57	6.54	6.51	6.47	6.42	6.36	6.30	6.23	6.16	6.08	6.00	5.92
	50	6.70	6.69	6.67	6.65	6.62	6.59	6.55	6.50	6.44	6.37	6.30	6.23	6.15	6.07	5.99
61	0	6.79	6.78	6.76	6.73	6.70	6.67	6.63	6.58	6.52	6.45	6.38	6.31	6.23	6.15	6.07
	10	6.88	6.87	6.85	6.82	6.78	6.75	6.71	6.66	6.60	6.53	6.46	6.39	6.31	6.23	6.15
	20	6.97	6.96	6.94	6.91	6.87	6.84	6.80	6.75	6.68	6.61	6.54	6.47	6.39	6.31	6.23
	30	7.05	7.04	7.02	6.99	6.95	6.91	6.87	6.82	6.76	6.70	6.63	6.55	6.47	6.39	6.37

TABLE II—*Showing the values of* S *and* H_0 *for each third of a month, and also of* B_0, *as affected by the annual inequality, and the constants of the equations.*

Date.	S	H_0	B_0
	Ft.	*Ft.*	*d. h. m.*
Jan. 1	0.92	20.09	1 23 9.0
11	0.93	20.07	9.1
21	0.95	20.04	9.3
Feb. 1	0.97	20.00	9.6
11	1.00	19.96	10.0
21	1.02	19.96	10.5
Mar. 1	1.03	19.98	11.0
11	1.03	20.01	11.6
21	1.02	20.03	12.3
April 1	1.01	20.06	13.0
11	1.00	20.08	13.7
21	0.97	20.11	14.4
May 1	0.93	20.14	15.0
11	0.90	20.15	15.5
21	0.87	20.16	15.9
June 1	0.84	20.16	16.3
11	0.83	20.16	16.6
21	0.81	20.16	16.9
July 1	0.82	20.17	17.0
11	0.83	20.17	16.9
21	0.86	20.18	16.6
Aug. 1	0.89	20.20	16.3
11	0.92	20.21	15.9
21	0.95	20.21	15.5
Sept. 1	0.98	20.22	15.0
11	1.00	20.23	14.4
21	1.01	20.25	13.7
Oct. 1	1.01	20.27	13.0
11	1.01	20.29	12.3
21	1.00	20.30	11.6
Nov. 1	0.98	20.31	11.0
11	0.96	20.31	10.5
21	0.94	20.30	10.0
Dec. 1	0.92	20.27	9.6
11	0.91	20.22	9.3
21	0.92	20.16	1 23 9.1

NOTE.—For the value of H_0 above mean low water, subtract 15.26 feet.

TABLE III—*Showing the inequalities resulting from friction and other causes, and depending upon the moon's transit, parallax, and declination.*

☽'s transit.	Equation.	☽'s parallax.	Equation.	☽'s dec.	Equation.
h. m.	*m.*	′ ″	*m.*	°	*m.*
0 00	8.0	54 00	15.0	0	0.0
30	7.8	30	14.0	2	0.1
1 00	7.5	55 00	13.0	4	0.2
30	6.9	30	12.0	6	0.4
2 00	6.0	56 00	11.0	8	0.6
30	5.0	30	10.0	10	0.9
3 00	4.0	57 00	9.0	12	1.2
30	3.0	30	8.0	14	1.6
4 00	2.0	58 00	7.0	16	2.0
30	1.1	30	6.0	18	2.5
5 00	0.5	59 00	5.0	20	3.0
30	0.2	30	4.0	22	3.6
6 00	0.0	60 00	3.0	24	4.3
30	0.2	30	2.0	26	5.1
7 00	0.5	61 00	1.0	28	6.0
30	1.1	30	0.0	30	7.0
8 00	2.0				
30	3.0				
9 00	4.0				
30	5.0				
10 00	6.0				
30	6.9	Constant 9*m.* 0		Constant.... 2*m.* 0	
11 00	7.5				
30	7.8				
Constant 4*m.* 0					

TABLE IV—*Showing the effect of the moon's diurnal tide upon the times and heights, and also of the term depending upon the fourth power of the moon's distance, contained in the last columns. The argument is* D, *taken one day in advance.*

☽'s dec.	Equations of high water.		Equations of low water.		Equations of semi-diurnal tide.	
°	*m.*	*Ft.*	*m.*	*Ft.*	*m.*	*Ft.*
+30	−3.0	+0.63	+3.0	−0.37	0.0	0.06
25	2.5	0.53	2.5	0.32	0.3	0.06
20	2.0	0.43	2.0	0.26	0.8	0.05
15	1.5	0.32	1.5	0.20	1.4	0.05
10	1.0	0.22	1.0	0.13	1.9	0.04
+ 5	−0.5	+0.11	+0.5	−0.07	2.5	0.04
0	0.0	0.00	0.0	0.00	3.0	0.03
− 5	+0.5	−0.11	−0.5	+0.07	3.5	0.02
10	1.0	0.22	1.0	0.13	4.1	0.02
15	1.5	0.32	1.5	0.20	4.6	0.01
20	2.0	0.43	2.0	0.26	5.2	0.01
25	2.5	0.53	2.5	0.32	5.7	0.00
−30	+3.0	−0.63	−3.0	+0.37	6.0	0.00

NOTE.—For lower transits the signs of the diurnal tide must be reversed.

TABLE V—*Showing the value of* C′ sin 2 v D_t v (104) *in tenths of minutes for each degree of declination and for each second of the value of* D_t v.

Dec.	Values of D_t v.																
	1″	2″	3″	4″	5″	6″	7″	8″	9″	10″	11″	12″	13″	14″	15″	16″	17″
°																	
1	.	.	.	.	.	.	.	3	3	4	4	5	5	5	6	6	7
2	.	.	.	.	.	.	.	6	7	8	8	9	10	11	12	12	13
3	.	.	.	.	.	.	.	9	10	11	12	13	15	16	17	18	19
4	.	.	.	.	.	..	..	12	13	15	16	18	20	21	23	25	26
5	.	.	.	.	..	..	..	15	16	19	20	22	25	26	29	31	32
6	.	.	.	.	..	..	16	18	20	23	25	27	30	32	34	37	40
7	.	.	.	..	..	..	19	21	23	27	29	31	35	37	40	43	46
8	.	.	..	..	..	..	22	24	27	30	33	36	40	42	46	49	52
9	.	.	..	..	..	20	24	27	30	34	37	41	44	47	51	54	..
10	.	.	..	..	..	22	26	30	33	37	41	46	49	53	57	60	..
11	.	..	..	..	..	25	29	33	37	40	45	50	54	58	62	66	..
12	.	..	..	..	22	27	31	36	40	44	49	54	58	63	67	72	..
13	.	..	..	..	24	29	34	39	43	47	53	58	63	68	72	78	..
14	.	..	..	20	25	31	36	42	46	51	57	62	67	72	77	..	..
15	.	..	16	22	27	33	38	44	49	55	60	66	71	76	82	..	..
16	.	12	17	24	28	35	41	47	52	58	64	70	76	81	86	..	..
17	6	12	18	25	30	37	43	50	55	61	68	74	80	86	..	..	..
18	6	13	19	26	32	39	45	52	58	64	71	78	84	90	..	..	..
19	6	13	20	27	33	40	47	55	60	67	75	82	86	..	..	..	..
20	7	14	21	28	35	42	49	57	63	70	78	86	90	..	..	..	..
21	7	15	22	29	36	44	51	59	66	73	81	90	..	..	..	..	..
22	7	15	23	30	37	46	53	61	69	76	84	..	..	..	..	..	..
23	8	16	23	31	39	47	55	63	71	79	..	..	..	..	..	..	..
24	8	16	24	32	40	49	57	65	73	82	..	..	..	..	..	..	..
25	8	17	25	33	41	50	59	67	75	..	..	..	..	..	..	..	..
26	8	17	26	34	43	52	61	69	..	..	..	..	..	..	..	..	..
27	9	18	27	35	44	53	63	..	..	..	..	..	..	..	..	..	..
28	9	18	27	36	45	54	..	..	..	..	..	..	..	..	..	..	..
29	9	19	28	37	46	..	..	..	..	..	..	..	..	..	..	..	..

NOTE.—When the arguments have the same signs, the quantities are positive; when different signs, negative.

TABLE VI—*Showing the value of* L′, *and the part of* L (99) *depending upon* β', *corresponding to any given value of the logarithmic tangent of* β' ( )

L′	0*m.*	1*m.*	2*m.*	3*m.*	4*m.*	5*m.*	6*m.*	7*m.*	8*m.*	9*m.*
m.										
0	. ...	6. 926	7. 227	7. 403	7. 528	7. 615	7. 704	7. 771	7. 829	7. 880
1	7. 926	7. 967	8. 005	8. 040	8. 072	8. 101	8. 130	8. 156	8. 181	8. 204
2	8. 227	8. 248	8. 268	8. 288	8. 306	8. 324	8. 341	8. 357	8. 373	8. 388
0	. ...	7. 926	8. 227	8. 403	8. 528	8. 625	8. 704	8. 771	8. 830	8. 881
10	8. 927	8. 969	9. 006	9. 042	9. 074	9. 104	9. 133	9. 159	9. 185	9. 209
20	9. 231	9. 253	9. 274	9. 293	9. 312	9. 333	9. 348	9. 365	9. 382	9. 398
30	9. 413	9. 428	9. 442	9. 457	9. 470	9. 484	9. 497	9. 510	9. 522	9. 534

NOTE.—In the first division of the table 0*m.*, 1*m.*, 2*m.*, &c., must be taken as tenths of a minute.

TABLE VII—*Showing the logarithmic sine and cosine of* $2(\psi-\psi')$ *to three places for each minute of* $(\psi-\psi')$.

$(\psi-\psi')$ h. m.	Sine.	Cosine.	$(\psi-\psi')$ h. m.	$(\psi-\psi')$ h. m.	Sine.	Cosine.	$(\psi-\psi')$ h. m.	$(\psi-\psi')$ h. m.	Sine.	Cosine.	$(\psi-\psi')$ h. m.
0 0	....	10.000	5 60	1 0	9.699	9.938	4 60	2 0	9.938	9.699	3 60
1	7.941	000	59	1	705	935	59	1	940	692	59
2	8.242	000	58	2	712	933	58	2	942	686	58
3	418	000	57	3	718	931	57	3	944	679	57
4	543	000	56	4	724	928	56	4	946	672	56
5	640	000	55	5	730	926	55	5	948	664	55
6	719	9.999	54	6	736	924	54	6	950	657	54
7	786	999	53	7	742	921	53	7	952	650	53
8	844	999	52	8	748	919	52	8	954	642	52
9	895	999	5 51	9	753	916	4 51	9	955	634	3 51
0 10	8.940	9.998	50	1 10	9.759	9.913	50	2 10	9.957	9.626	50
11	982	998	49	11	764	911	49	11	959	618	49
12	9.019	998	48	12	769	908	48	12	961	609	48
13	054	997	47	13	774	905	47	13	962	601	47
14	086	997	46	14	779	902	46	14	964	592	46
15	116	996	45	15	784	899	45	15	966	583	45
16	144	996	44	16	789	897	44	16	967	574	44
17	170	995	43	17	794	894	43	17	969	564	43
18	194	995	42	18	799	890	42	18	970	554	42
19	218	994	5 41	19	804	887	4 41	19	972	544	3 41
0 20	9.240	9.993	40	1 20	9.808	9.884	40	2 20	9.973	9.534	40
21	260	993	39	21	813	881	39	21	974	523	39
22	281	992	38	22	817	878	38	22	976	513	38
23	300	991	37	23	821	874	37	23	977	501	37
24	318	990	36	24	826	871	36	24	978	490	36
25	335	990	35	25	830	868	35	25	979	478	35
26	352	989	34	26	834	864	34	26	981	466	34
27	368	988	33	27	838	861	33	27	982	453	33
28	384	987	32	28	842	857	32	28	983	440	32
29	399	986	5 31	29	846	853	4 31	29	984	427	3 31
0 30	9.413	9.985	30	1 30	9.849	9.849	30	2 30	9.985	9.413	30
31	427	984	29	31	853	846	29	31	986	399	29
32	440	983	28	32	857	842	28	32	987	384	28
33	453	982	27	33	861	838	27	33	988	368	27
34	466	981	26	34	864	834	26	34	989	352	26
35	478	979	25	35	868	830	25	35	990	335	25
36	490	978	24	36	871	826	24	36	990	318	24
37	501	977	23	37	874	821	23	37	991	300	23
38	513	976	22	38	878	817	22	38	992	281	22
39	523	974	5 21	39	881	813	4 21	39	993	260	3 21
0 40	9.534	9.973	20	1 40	9.884	9.808	20	2 40	9.993	9.240	20
41	544	972	19	41	887	804	19	41	994	218	19
42	554	970	18	42	890	799	18	42	995	194	18
43	564	969	17	43	894	794	17	43	995	170	17
44	574	967	16	44	897	789	16	44	996	144	16
45	583	966	15	45	899	784	15	45	996	116	15
46	592	964	14	46	902	779	14	46	997	086	14
47	601	962	13	47	905	774	13	47	997	054	13
48	609	961	12	48	908	769	12	48	998	019	12
49	618	959	5 11	49	911	764	4 11	49	998	8.982	3 11
0 50	9.626	9.957	10	1 50	9.913	9.759	10	2 50	9.998	8.940	10
51	634	955	9	51	916	753	9	51	999	895	9
52	642	954	8	52	919	748	8	52	999	844	8
53	650	952	7	53	921	742	7	53	999	786	7
54	657	950	6	54	924	736	6	54	999	719	6
55	664	948	5	55	926	730	5	55	10.000	640	5
56	672	946	4	56	928	724	4	56	000	543	4
57	679	944	3	57	931	718	3	57	000	418	3
58	686	942	2	58	933	712	2	58	000	242	2
59	692	940	1	59	935	705	1	59	000	7.941	1
60	9.699	9.938	5 0	1 60	9.938	9.699	4 0	2 60	10.000	....	3 0

TABLE VIII—*Showing the effect of the solar diurnal tide upon the time of high water for every hour of the moon's transit, and for the first of each month, expressed in tenths of a minute.*

Month.	HOURS OF MOON'S TRANSIT IN ASTRONOMICAL TIME.																						
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Jan.....	+13	+14	+15	+15	+15	+14	+13	+11	+ 6	0	— 6	—11	—13	—14	—15	—15	—15	—14	—13	—11	— 6	0	+ 6	+11
Feb.....	10	12	12	12	12	12	10	8	4	0	4	8	10	12	12	12	12	12	10	8	5	0	5	8
Mar.....	+ 4	+ 5	+ 5	+ 5	+ 5	+ 5	+ 4	+ 3	+ 2	0	— 2	— 3	— 4	— 5	— 5	— 5	— 5	— 5	— 4	— 3	— 2	0	+ 2	+ 3
Apr.....	— 2	— 3	— 3	— 3	— 3	— 3	— 2	— 2	— 1	0	+ 1	+ 2	+ 2	+ 3	+ 3	+ 3	+ 3	+ 3	+ 2	+ 2	+ 1	0	— 1	— 2
May....	9	10	10	10	10	9	7	6	3	0	3	6	7	9	10	10	10	10	9	7	4	0	4	7
June....	12	14	14	14	14	13	12	10	5	0	5	10	12	13	14	14	14	14	12	10	6	0	6	10
July....	13	15	15	15	15	15	14	11	6	0	6	11	14	15	15	15	15	15	13	11	6	0	6	11
Aug....	9	12	12	12	12	12	11	8	4	0	4	8	11	12	12	12	12	12	10	8	5	0	4	8
Sept....	— 3	— 5	— 5	— 5	— 5	— 5	— 4	— 3	— 2	0	+ 2	+ 3	+ 4	+ 5	+ 5	+ 5	+ 5	+ 5	+ 4	+ 3	+ 2	0	— 2	— 3
Oct.....	+ 2	+ 3	+ 3	+ 3	+ 3	+ 3	+ 2	+ 2	+ 1	0	— 1	— 2	— 2	— 3	— 3	— 3	— 3	— 3	— 2	— 2	— 1	0	+ 1	+ 2
Nov....	9	10	10	10	10	10	8	6	3	0	3	6	8	10	10	10	10	10	9	7	4	0	4	7
Dec.....	+12	+14	+14	+14	+14	+13	+12	+10	+ 5	0	— 5	—10	—12	—13	—14	—14	—14	—13	—12	—10	— 6	0	+ 6	+10

NOTE.—For lower transits the signs must be reversed.

TABLE IX—*Showing the effect of the solar diurnal tide upon the time of low water for every hour of the moon's transit, and for the first of each month, expressed in tenths of a minute.*

Month.	HOURS OF MOON'S TRANSIT IN ASTRONOMICAL TIME.																						
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Jan.....	—13	—11	— 6	0	+ 6	+11	+13	+14	+15	+15	+15	+14	+13	+11	+ 6	0	— 6	—11	—13	—14	—15	—15	—15	—14
Feb.....	9	8	4	0	4	8	9	10	12	12	12	10	9	7	4	0	4	7	9	10	12	12	12	10
Mar.....	— 3	— 3	— 2	0	+ 2	+ 3	+ 3	+ 4	+ 5	+ 5	+ 5	+ 5	+ 4	+ 3	+ 2	0	— 2	— 3	— 4	— 5	— 5	— 5	— 5	— 4
April...	+ 2	+ 2	+ 1	0	— 1	— 2	— 2	— 3	— 3	— 3	— 3	— 3	— 2	— 2	— 1	0	+ 1	+ 2	+ 2	+ 3	+ 3	+ 3	+ 3	+ 3
May....	9	7	3	0	3	7	9	9	10	10	10	9	8	7	3	0	3	7	8	9	10	10	10	9
June....	12	10	6	0	6	10	12	12	14	14	14	13	12	11	5	0	5	11	12	13	14	14	14	12
July....	13	11	6	0	6	11	13	14	15	15	15	14	13	11	6	0	6	11	13	14	15	15	15	14
Aug....	9	8	4	0	4	8	9	10	12	12	12	10	9	8	4	0	4	8	9	10	12	12	12	10
Sept....	+ 3	+ 3	+ 2	0	— 2	— 3	— 3	— 4	— 5	— 5	— 5	— 5	— 4	— 3	— 2	0	+ 2	+ 3	+ 4	+ 5	+ 5	+ 5	+ 5	+ 4
Oct.....	— 2	— 2	— 1	0	+ 1	+ 2	+ 2	+ 3	+ 3	+ 3	+ 3	+ 3	+ 2	+ 2	+ 1	0	— 1	— 2	— 2	— 3	— 3	— 3	— 3	— 3
Nov....	9	7	3	0	3	7	9	9	10	10	10	9	9	7	3	0	3	7	9	9	10	10	10	9
Dec.....	—12	—11	— 6	0	+ 6	+11	+12	+12	+14	+14	+14	+13	+12	+10	+ 5	0	— 5	—10	—12	—13	—14	—14	—14	—12

NOTE.—For lower transits the signs must be reversed.

TABLE X—*Showing the effect of the solar diurnal tide upon the height of high water for every hour of the moon's transit, and for the first of each month, expressed in hundredths of a foot.*

Month.	HOURS OF MOON'S TRANSIT IN ASTRONOMICAL TIME.																						
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Jan.....	—18	—13	— 6	0	+ 7	+13	+18	+22	+24	+24	+24	+22	+18	+13	+ 6	0	— 7	—13	—18	—22	—24	—24	—24	—22
Feb.....	13	10	4	0	5	10	13	16	18	19	18	16	13	10	4	0	5	10	13	16	18	19	18	16
Mar....	— 6	— 4	— 2	0	+ 2	+ 4	+ 6	+ 7	+ 8	+ 8	+ 7	+ 7	+ 6	+ 4	+ 2	0	— 2	— 4	— 6	— 7	— 8	— 8	— 7	— 7
April...	+ 3	+ 2	+ 1	0	— 1	— 2	— 4	— 4	— 5	— 5	— 4	— 4	— 3	— 2	— 1	0	+ 1	+ 2	+ 4	+ 4	+ 5	+ 5	+ 4	+ 4
May....	11	8	4	0	4	9	11	14	15	15	14	13	11	8	4	0	4	9	11	14	15	15	14	13
June....	16	11	5	0	6	12	16	20	22	23	22	21	16	11	5	0	6	12	16	20	22	23	22	21
July....	18	13	6	0	7	13	18	22	24	24	24	22	18	13	6	0	7	13	18	22	24	24	23	22
Aug....	13	10	4	0	5	10	13	16	18	19	18	16	13	10	4	0	5	10	13	16	18	19	18	16
Sept....	+ 6	+ 4	+ 2	0	— 2	— 4	— 6	— 7	— 8	— 8	— 7	— 7	— 6	— 4	— 2	0	+ 2	+ 4	+ 6	+ 7	+ 8	+ 8	+ 7	+ 7
Oct.....	— 3	— 2	— 1	0	+ 1	+ 2	+ 4	+ 4	+ 5	+ 5	+ 4	+ 4	+ 3	+ 2	+ 1	0	— 1	— 2	— 4	— 4	— 5	— 5	— 4	— 4
Nov....	11	8	4	0	4	9	11	14	15	15	14	13	11	8	4	0	4	9	11	14	15	15	14	13
Dec.....	—16	—11	— 5	0	+ 6	+12	+16	+20	+22	+23	+22	+21	+16	+11	+ 5	0	— 6	—12	—16	—20	—22	—23	—22	—21

NOTE.—For lower transits the signs must be reversed.

TABLE XI—*Showing the effect of the solar diurnal tide upon the height of low water for every hour of the moon's transit, and for the first of each month, expressed in hundredths of a foot.*

Month.	HOURS OF MOON'S TRANSIT IN ASTRONOMICAL TIME.																							
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Jan.....	+11	+13	+14	+14	+13	+11	+ 9	+ 6	+ 3	0	− 4	− 8	−11	−13	−14	−14	−13	−11	− 9	− 6	− 3	0	+ 4	+ 8
Feb.....	8	10	11	11	10	8	6	4	2	0	2	6	8	10	11	11	10	8	6	4	2	0	2	6
Mar....	+ 3	+ 4	+ 5	5	+ 4	+ 3	+ 3	+ 2	+ 1	0	− 1	− 3	− 3	− 4	− 5	− 5	− 4	− 3	− 3	− 2	− 1	0	+ 1	+ 3
April...	− 2	− 2	− 2	− 2	− 2	− 2	− 2	− 1	− 0	0	+ 0	+ 1	+ 2	+ 2	+ 2	+ 2	+ 2	+ 2	+ 2	+ 1	+ 1	0	− 1	− 1
May....	6	8	9	9	8	6	5	3	1	0	2	5	6	8	9	9	8	6	5	3	2	0	2	5
June....	10	12	13	13	12	10	8	5	3	0	3	7	10	12	13	13	12	10	8	5	3	0	3	7
July....	11	13	14	14	13	11	9	6	3	0	4	8	11	13	14	14	13	11	9	6	3	0	4	8
Aug....	8	10	11	11	10	8	6	4	2	0	2	6	8	10	11	11	10	8	6	4	2	0	2	6
Sept....	− 3	− 4	− 5	− 5	− 4	− 3	− 3	− 2	− 1	0	+ 1	+ 3	+ 3	+ 4	+ 5	+ 5	+ 4	+ 3	+ 3	+ 2	+ 1	0	− 1	− 3
Oct.....	+ 2	+ 2	+ 2	+ 2	+ 2	+ 2	+ 2	+ 1	+ 0	0	− 0	− 1	− 2	− 2	− 2	− 2	− 2	− 2	− 2	− 1	− 1	0	+ 1	+ 1
Nov....	6	8	9	9	8	6	5	3	1	0	2	5	6	8	9	9	8	6	5	3	2	0	2	5
Dec.....	+10	+12	+13	+13	+12	+10	+ 8	+ 5	+ 3	0	− 3	− 7	−10	−12	−13	−13	−12	−10	− 8	− 5	− 3	0	+ 3	+ 7

NOTE.—For lower transits the signs must be reversed.

Example of the computation of a tidal ephemeris for the first part of January, 1871.

A	a	B	C	c	D	d	L′	e	f	g	h	i	j	B_0
d. h. m.	*m.*	*h. m.*	′ ″	″	°	″	*m.*	*m.*	*m.*	*m.*	*m.*	*m.*	*m.*	*m.*
Dec. 30 6 55.0	+2.7	6 52.3	54 47	—1.0	+ 3	+11.6	44.4	13.0	11.3	0.4	14.3	0.1	2.8	9.0
31 7 36.5	3.2	7 33.3	54 22	0.7	8	10.9	53.6	12.1	13.3	1.5	14.6	0.6	2.2	9.0
Jan. 1 8 18.8	3.7	8 15.1	54 9	—0.3	12	9.9	58.3	10.9	14.4	2.5	14.8	1.2	1.7	9.0
2 9 2.7	4.2	8 58.5	54 5	0.0	16	8.5	58.4	10.0	15.0	4.0	14.7	2.0	1.3	9.0
3 9 48.9	4.7	9 44.2	54 10	+0.3	19	6.6	54.3	9.1	14.4	5.6	14.3	2.8	0.8	9.0
4 10 37.2	5.1	10 32.1	54 23	0.6	22	4.4	47.1	8.3	13.1	6.8	13.5	3.5	0.6	9.0
5 11 27.5	5.6	11 21.9	54 42	0.8	23	+1.7	37.4	7.6	11.4	7.7	12.7	4.0	0.5	9.1
6 12 19.2	6.0	12 13.9	55 6	1.0	23	—1.2	27.2	7.0	9.0	8.0	11.8	4.0	0.5	9.1

E	Δ^1	Δ^2	δ^1	k	l	m	t.h.w	Q	n	$\frac{1}{3}n$	A_2	Δ^1	Δ^2	δ^1	H_0+A_2	p	q	r	h.h.w
d. h. m.	*m.*	*m.*	*m.*	*m.*	*m.*	*m.*	*m.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*				*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
Jan. 1 7 30.3	52.9	. .	26.9	—0.8	+1.3	+0.5	31	3.35	—1.55	—.52	3.87	+.03	. .	—.00	23.96	+.18	+.22	+.40	24.32
19 57.2	26.4		26.0			+0.1	57				3.87	.01		+.03	23.95			.45	23.50
2 8 23.2	48.7	—4.2	24.8	1.2	0.9	—0.3	23	3.40	1.50	.50	3.90	.14	+.11	.06	23.99	.26	.24	.50	24.49
20 48.0	24.3	0.5	23.9			0.8	49				3.96	.07	.01	.08	24.05			.54	23.51
3 9 11.9	45.2	3.5	23.0	1.6	+0.4	1.2	11	3.61	1.29	.43	4.04	.19	.05	.08	24.13	.34	.24	.58	24.71
21 34.9	22.6	0.4	22.2			1.6	36				4.12	.09	.01	.11	24.21			.62	23.59
4 9 57.1	42.1	3.1	21.4	1.9	0.0	1.9	55	3.89	1.01	.34	4.23	.20	.01	.10	24.32	.41	.24	.65	24.97
22 18.5	21.0	0.4	20.7			2.3	21				4.33	.10	.00	.10	24.42			.68	23.74
5 10 39.2	39.9	2.2	20.3	2.2	—0.5	2.7	37	4.19	0.71	.24	4.43	.19	+.01	.09	24.52	.47	.24	.71	25.23
22 59.5	20.0	0.3	19.6			3.0	62				4.52	.09	.00	.10	24.61			.72	23.89
6 11 19.1	38.7	1.2	19.5	2.3	0.9	3.2	16	4.48	0.42	.14	4.62	.17	—.02	.08	24.71	.49	.23	.72	25.43
23 38.6	19.3	0.2	19.2			3.4	42				4.70	.08	.00	.09	24.79			.71	24.08
7 11 57.8	38.0	—0.7	19.1	2.3	1.2	3.5	54	4.74	—0.16	—.05	4.79	+.12	—.05	.07	24.88	.49	.20	.69	25.57
8 0 16.9	19.0	0.1	18.9			3.5	20				4.86	.06	.01	+.05	24.95			.66	24.29
12 35.8	. . .	. .	19.0	2.2	—1.3	3.5	32	4.92	+0.02	+.01	4.91	. .	. .		25.00	+.47	+.16	+.63	25.63

E′	k′	l′	m′	t.l.w	A'_2	$H_0-A'_2$	p′	q′	r′	h.l.w	M	S	Log. sin 2 B	Log. cos 2 B.	S cos 2 B	
															Log.	No.
d. h. m.	*m.*	*m.*	*m.*	*m.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*				*Ft.*
Jan. 1 13 43.7	+0.8	+1.4	+2.2	46	3.86	16.23	+.11	+.08	+.19	16.42	4.15	0.92	9.644*n*	9.953*n*	9.917*n*	—0.83
2 2 10.2			2.5	8	3.88	16.21			.21	16.01						
14 35.6	1.2	1.5	2.7	38	3.93	16.16	.16	.06	.22	16.38	3.97	0.92	9.862	9.837	9.801	0.63
3 2 0.0			2.9	57	4.00	16.09			.23	15.86						
15 23.4	1.6	1.5	3.1	26	4.08	16.01	.21	+.03	.24	16.25	3.86	0.92	9.966	9.582	9.548	0.35
4 3 46.0			3.2	43	4.17	15.92			.25	15.67						
16 7.8	1.9	1.5	3.4	11	4.28	15.81	.25	.00	.25	16.06	3.79	0.92	10.000	8.090*n*	8.054*n*	—0.01
5 4 28.8			3.6	25	4.38	15.71			.25	15.46						
16 49.3	2.2	1.5	3.7	53	4.48	15.61	.28	—.03	.25	15.86	3.76	0.92	9.967	9.576*p*	9.540*p*	+0.35
6 5 9.3			3.7	6	4.57	15.52			.24	15.28						
17 28.8	2.3	1.4	3.7	32	4.66	15.43	.30	.06	.24	15.67	3.78	0.92	9.842	9.857	9.821	0.66
7 5 48.2			3.7	44	4.75	15.34			.23	15.11						
18 7.3	2.3	1.3	3.6	11	4.83	15.26	.30	.09	.21	15.47	3.86	0.93	9.501*n*	9.977	9.941	0.87
8 6 26.4			3.5	23	4.89	15.20			.19	15.01						
18 45.3	+2.2	+1.1	+3.3	49	4.93	15.16	+.28	—.11	+.17	15.33	4.00	0.93	9.083*p*	9.997*p*	9.965*p*	+0.92

E′—Continued.	M + S cos 2 B		Log. S sin 2 B	Log. tan β′	Log. M	Log. M^2	M^2	M^2+S^2	2 M S cos 2 B		M^2+S^2+2 M S cos 2 B		Log. Q
	No.	Log.							Log.	No.	No.	Log.	
d. h. m.	*Ft.*												
Jan. 1 13 43.7	3.32	0.521	9.608*p*	9.087*p*	0.618	1.236	17.22	18.07	0.836*n*	—6.85	11.22	1.050	0.525
2 2 10.2													
14 35.6	3.34	0.524	9.826	9.302	0.599	1.198	15.78	16.63	.701	5.02	11.61	1.065	0.532
3 2 0.0													
15 23.4	3.51	0.545	9.930	9.385	0.587	1.174	14.93	15.78	.436	2.73	13.05	1.116	0.558
4 3 46.0													
16 7.8	3.78	0.578	9.965	9.388	0.579	1.158	14.39	15.24	8.934*n*	—0.09	15.15	1.180	0.590
5 4 28.8													
16 49.3	4.11	0.614	9.933	9.319	0.575	1.150	14.13	14.99	9.416*p*	+2.61	17.60	1.245	0.622
6 5 9.3													
17 28.8	4.44	0.647	9.809	9.162	0.577	1.154	14.26	15.12	0.699	5.00	20.12	1.303	0.651
7 5 48.2													
18 7.3	4.73	0.675	9.468*p*	8.793*p*	0.587	1.174	14.93	15.79	0.829	6.74	22.53	1.352	0.676
8 6 26.4													
18 45.3	4.92	0.692	9.051*n*	8.359*n*	0.602	1.204	16.00	16.86	0.868*p*	+7.38	24.24	1.385	0.692

APPENDIX No. 6.

MODE OF FORMING A BRIEF TIDE TABLE FOR A CHART.

BY R. S. AVERY.

The process here described is designed for obtaining such results as are now generally given in a brief tabular form on charts of portions of the western coast of the United States. It became apparent some time ago to the officers of the Coast Survey that the tidal notes furnished on these charts did not enable them to conveniently compute the average tides when wanted for their work, and accordingly Mr. Hilgard, the assistant in charge of the Office, who had become well acquainted with their wants, directed me to endeavor to devise something better. My experience in working on these tides enabled me soon to design the outline of the form now used, which, after various emendations by him and others, being adopted, I planned the scheme of computation that has been followed. Several short series of observations were discussed and tables furnished in accordance with this method before those I shall treat of in this paper were undertaken. The method only deals with the most prominent features of the subject, and yields a first approximation to the effects of the changes in transits, phases, and declinations. Yet, brief as is the final statement of results, it embraces twenty-eight numerical determinations with regard to the general characteristics of the tides at the place of observation. These values are assumed to be average ones, and will be nearer to the truth the longer the series, if proper conditions are fulfilled. Continuous observations of the times and heights of both high and low waters for a month is about the least that will suffice for the formation of a good table by this process.

We proceed as follows: First, we make a primary reduction of the observations in the usual form, which embraces a tabular statement of the times and heights of all the high and low waters, of the times of upper and lower transits of the moon, and of the computed lunitidal intervals for both high and low waters, the lower transits and the intervals derived from them being written in red ink to distinguish them from the others, which are in black. We then plot the heights of high and also of low waters, and in like manner the lunitidal intervals for both, the plottings being arranged in the most convenient way for the work that is to follow. Connecting the points by curves, as it becomes obvious that they should be, we get eight curves, two for the heights of high water, two for the heights of low water, two for the lunitidal intervals for high water, and two for those of low water. We distinguish the curves for lower transit tides by drawing them with red ink, making them agree in color with the numbers on the reduction sheets from which they are derived. It is generally found most convenient to plot all the heights for both high and low waters on one roll, and all the intervals for both on another. We then mark with the appropriate symbols, on these plottings, the times of the moon's cardinal phases and declinations, advancing them as many hours to the right as the mean interval amounts to, in order to refer effects directly to their assumed causes. The plottings are then ready for use.

The next step is to compute *the plane of reference.* This is found from the heights of the low waters as follows: It is apparent from an inspection of the curves for these that the black curve lies about half the time below the red one, and about half the time above it. Now, we use for these tides the mean of all the ordinates for the lower branches of these curves for the plane of reference. We therefore tabulate all the ordinates from which these branches were plotted, observing to use only complete ones, or such as admit of being easily assumed to be so, and in doing so we keep those for each branch separate, and find the separate sums. We then bring these sums together and find the mean of all, which we use as the plane of reference. In all the work that follows this, the height ordinates are either read from the level of the plane of reference or reduced to it.

We next classify for four phases of the moon, extending it to both high and low waters (H. W. L. W.) and to the black and red curves (b r) for each, according to the following form:

New ☾ = ●				1st Q = ☽				Full ☾ = ○				3d Q = ☾			
H. W.		L. W.		H. W.		L. W.		H. W.		L. W.		H. W.		L. W.	
b	r	b	r	b	r	b	r	b	r	b	r	b	r	b	r
s_0	s_1	s_2	s_3	s_4	s_5	s_6	s_7	s_8	s_9	s_{10}	s_{11}	s_{12}	s_{13}	s_{14}	s_{15}

We then read off the ordinates from the plotting, and arrange them under the appropriate heads above given, taking an ordinate from each of the four curves at each phase of the moon, and continue this as far as the plotting extends. We then add up these sixteen columns and place the sums of the last eight under those of the first eight in the same order. Adding these again, we get eight sums. Then placing each sum that is under r under the b preceding and adding again, we reduce the whole to four sums. Then dividing each of these by the whole number of ordinates that have been brought together to produce it, we obtain four mean values. Subtract the two last of these from the two first, algebraically with regard to signs, and divide each difference by 2. The two results thus obtained, taken with the proper signs, show the average effects due to the moon's phases, and appear under the heads of "Spring tides" and "Neap tides" in the final table. These operations may be symbolized in the following formulæ:

$$
\begin{array}{ll}
s_0+s_8=S_0 & S_0+S_1=S' \\
s_1+s_9=S_1 & S_2+S_3=S'' \\
s_2+s_{10}=S_2 & S_4+S_5=S''' \\
s_3+s_{11}=S_3 & S_6+S_7=S^{iv} \\
s_4+s_{12}=S_4 & \dfrac{S'}{n}=a, \quad \dfrac{S''}{n}=b, \quad \dfrac{S'''}{n_1}=a_1, \quad \dfrac{S^{iv}}{n_1}=b_1 \\
s_5+s_{13}=S_5 & \\
s_6+s_{14}=S_6 & \dfrac{a-a_1}{2}=\pm N, \quad \dfrac{b-b_1}{2}=\mp N_1 \\
s_7+s_{15}=S_7 &
\end{array}
$$

Where s_0, s_1, s_2, &c., denote the sums of the several columns; S_0, S_1, S_2, &c., the first set of combined sums; S', S'', S''', S^{iv}, the next set of combined sums; n and n_1, the number of ordinates brought together; a and a_1, the resulting mean values for high waters; b and b_1 for low waters; and N and N_1, the final results for high and low waters respectively, each of them to be taken with the upper sign for spring tides and the lower sign for neap tides.

This process is based on the general deductions that the effects at new and full moon are nearly alike, and those at the first and third quarters nearly alike; those for upper and lower transits nearly alike in magnitude, but with opposite signs; and that, ordinarily, oscillations above and below the mean level are nearly equal to each other.

We next classify for four positions of the moon in declination, namely, greatest north, passing through zero going south, greatest south, and passing through zero returning north; extending it to both high and low waters (H. W. L. W.) and to the black and red curves (b r) for each, according to the following form:

☾ Dec. N.				☾ Dec. 0				☾ Dec. S.				☾ Dec. 0			
H. W.		L. W.		H. W.		L. W.		H. W.		L. W.		H. W.		L. W.	
b	r	b	r	b	r	b	r	b	r	b	r	b	r	b	r
s_0	s_1	s_2	s_3	s_4	s_5	s_6	s_7	s_8	s_9	s_{10}	s_{11}	s_{12}	s_{13}	s_{14}	s_{15}

We then read off the ordinates from the plotting and arrange them under the appropriate heads above given, taking an ordinate for each of the four curves at each of the above positions of the moon, continuing as far as the plotting extends. We then add up these sixteen columns and place the sums of the last eight under those of the first eight, changing the order of the last

eight so as to bring the sums of the second ones of each pair of the last eight under the sums of the first ones of the first eight, and *vice versa.* We then add again and compute the mean values. The first four of these results appear in their proper places in the final table, and the half-sum of each pair of the other four is also placed in the same table. The operations may, perhaps, be more briefly and clearly represented by the following formulæ:

$$\begin{aligned} s_0+s_9 &= S_0 & \frac{S_0}{n}&=a, \quad \frac{S_1}{n}=a_2, \quad \frac{S_2}{n}=b, \quad \frac{S_3}{n}=b_2, \\ s_1+s_8 &= S_1 \\ s_2+s_{11} &= S_2 \\ s_3+s_{10} &= S_3 & \frac{S_4+S_5}{2n_1}&=a_1, \quad \frac{S_6+S_7}{2n_1}=b_1. \\ s_4+s_{13} &= S_4 \\ s_5+s_{12} &= S_5 \\ s_6+s_{15} &= S_6 \\ s_7+s_{14} &= S_7 \end{aligned}$$

Where s_0, s_1, s_2, &c., denote the sums of the several columns; S_0, S_1, S_2, &c., the first set of combined sums; n and n_1 the number of ordinates brought together to make these last; a, a_1, a_2, the resulting mean values for high waters; and b, b_1, b_2, for low waters.

This process is based on the general deductions that upper transits at maximum north declination are followed by nearly the same effects as lower transits at maximum south declination, and *vice versa;* that similar effects are observable where the declination is zero according as the moon is going north or south; that the average effects for these last positions should, for a long period, be nearly equal; and, lastly, that oscillations above and below the mean level are in general nearly equal.

We next take the plotting of the lunitidal intervals, and treat it in the same way we did the plotting for heights in the process just described. We shall thus obtain a set of results which we will here indicate by corresponding capital letters, namely: A, A_2, B, B_2, A_1, B_1.

We may now arrange all these results in a table of the following form:

Moon's declination.	Moon's upper meridian passage.				Moon's lower meridian passage.			
	High water.		Low water.		High water.		Low water.	
	Interval.	Height.	Interval.	Height.	Interval.	Height.	Interval.	Height.
Greatest north	A	a	B	b	A_2	a_2	B_2	b_2
Zero	A_1	a_1	B_1	b_1	A_1	a_1	B_1	b_1
Greatest south.....	A_2	a_2	B_2	b_2	A	a	B	b

As an example of this mode of forming a tide-table we will take the work for Sitka, Alaska Territory. We have three short sets of observations of tides made at this place. The first was made in 1841 with a self-registering gauge, and extended from April 17 (N. S.) to May 19. The curves of observation are given on a plate in the *Bulletin de la classe physico-mathématique de l'Académie des Sciences de St. Petersbourg,* Tome I, No. 6, from which we took them on tracing-vellum. The plottings of the lunitidal intervals showed that the dates given should be diminished by unity, the reason for it being that the Russian observers doubtless carried their dates to the eastward from Europe, while the Americans carried theirs westward. The heights were read from the traced line of mean level; consequently high waters were treated as positive numbers, and low waters as negative ones. The second set of observations was made in 1855, extending from June 5 to October 13, with the loss of half a month in September. We are indebted to the Russians also for this set, which was made in the mean astronomical time kept at the magnetic observatory, and in English feet and inches, and had to be reduced to mean civil time, and to feet and decimals. The third set was made by the party of Assistant G. Davidson, of the United States Coast Survey, in 1867, extending from August 20 to October 28, the numbers for high water being smallest, or decreasing with rise of tide.

These sets of observations were all reduced and plotted as described in the foregoing paragraphs, and then the plane of reference found for each set as follows in accordance with what has been said:

From the plottings of the heights for 1867, (see the specimens of these plottings, Sketch No. 29:)

Ft.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	
14.0	15.4	15.6	16.1	15.0	203.0	13 ordinates.
13.5	15.0	15.7	16.0	15.2	192.1	13 "
14.0	14.0	15.6	15.5	16.5	184.2	12 "
14.1	14.0	15.0	14.8	15.8	171.4	12 "
14.5	13.8	14.7	14.4	16.3	183.4	12 "
15.7	14.1	14.3	13.6	16.6	———	—
16.6	14.7	14.9	13.2	16.8	934.1	(62 "
17.1	15.0	14.6	13.0	15.4		———
17.4	14.9	15.7	12.6	14.1		15.06
17.3	15.0	15.9	13.4	13.9		
16.9	15.3	16.3	14.3	13.7		
16.2	15.4	15.9	14.5	14.1		
15.7	15.5					
203.0	192.1	184.2	171.4	183.4		

We will take 15.0 feet for the plane of reference for this set of observations.

In the same way we obtain 5.4 feet for the plane of reference for the observations of 1855, and 5.6 feet for that of the observations of 1841. Then for the following operations the ordinates are read from all the plottings in the same way, and those above the plane of reference are treated as positive, those below it as negative. In reading such ordinates it is best to assume an average curve to read to and not follow strictly the various little irregularities of the broken line which represents the observations.

We next read ordinates from the plottings, and classify for four phases of the moon as follows, (see the specimens of these plottings, Sketch No. 29:)

Obs.	New ☾=●				1st Q=☽				Full ☾=○				3d Q=☾			
	H. W.		L. W.		H. W.		L. W.		H. W.		L. W.		H. W.		L. W.	
	b	*r*	*b*	*r*	*b*	*r*	*b*	*r*	*b*	*r*	*b*	*r*	*b*	*r*	*b*	*r*
1867													9.4	7.2	1.1	3.1
	10.4	9.8	−2.3	0.1	5.9	7.5	3.3	1.1	9.6	9.8	0.8	−0.4	9.3	7.4	0.4	3.7
	10.0	10.4	−0.9	−0.8	7.0	7.7	4.3	1.8	10.7	10.0	−0.4	1.0	8.7	7.8	0.5	3.6
	10.2	10.9	2.0	−0.8												
1855													9.5	8.4	3.2	0.9
	10.4	8.4	−1.6	3.6	6.5	8.0	1.9	3.0	8.8	11.7	4.0	−2.2	10.0	7.9	2.0	1.6
	10.2	8.5	−1.0	4.0	6.5	8.9	2.9	2.2	9.5	11.4	2.8	−2.8	9.9	7.1	1.3	2.6
	10.0	8.6	−0.7	3.0	6.6	9.3	4.2	1.7	10.1	11.6	1.4	−2.2	9.8	7.3	1.7	5.0
					6.7	9.2	5.1	1.4	11.6	11.2	−0.2	−0.3	8.0	6.6	1.1	4.9
	9.9	10.8	2.1	0.8												
1841	10.7	8.7	−1.8	1.7	7.8	7.4	0.2	3.3	8.5	10.4	2.8	−1.2	7.5	7.0	4.2	1.9
	81.8	76.1	−4.2	11.6	47.0	58.0	21.9	14.5	68 8	76.1	11.2	−8.1	82.1	66.7	15.5	27.3
	68.8	76.1	11.2	−8.1	82.1	66.7	15.5	27.3								
	150.6	152.2	7.0	3.5	129.1	124.7	37.4	41.8								
	152.2		3.5		124.7		41.8									
30)	302.8		10.5		253.8		79.2		(32							
	10.1		0.3		7.9		2.5									
	7.9		2.5													
2)	2.2		−2.2													
Res'lts	±1.1		∓1.1													

We next read ordinates from the plottings and classify for four positions of the moon in declination as follows, (see the specimens of these plottings, Sketch No. 29:)

Obs.	☾ Dec. N.				☾ Dec. 0				☾ Dec. S.				☾ Dec. 0			
	H. W.		L. W.		H. W.		L. W.		H. W.		L. W.		H. W.		L. W.	
	b	r	b	r	b	r	b	r	b	r	b	r	b	r	b	r
1867	9.9	7.8	—0.2	3.5	9.8	9.8	—0.5	0.3	6.1	7.3	3.6	0.9	9.8	9.7	0.0	—0.4
	9.2	7.5	0.6	3.9	9.9	10.4	—0.9	—0.5	6.7	7.8	4.1	1.6	10.3	9.7	0.0	0.6
	8.8	7.3	—1.5	2.5	9.6	10.5	0.7	0.1								
1855													9.7	7.5	1.7	1.5
	10.3	8.5	—1.3	3.9	6.3	8.2	2.1	2.7	8.7	11.8	4.0	—2.2	10.0	8.6	2.4	1.2
	10.4	8.4	—1.0	4.2	7.2	8.4	1.3	2.7	8.3	10.9	4.2	—1.5	10.2	9.1	1.0	—0.5
	9.5	7.6	—0.3	4.4	8.8	9.2	0.8	2.1	7.4	9.9	4.8	—0.1	11.6	11.2	0.6	—0.3
	8.6	7.3	1.6	5.3					6.9	9.0	5.3	1.1	11.7	11.2	—0.4	—0.2
	8.2	6.6	1.1	4.8	9.7	10.4	1.8	1.1								
1841													9.6	8.6	2.2	2.0
	10.1	7.8	—1.1	3.3	8.3	9.3	1.3	2.0	7.8	9.6	3.5	—1.2	8.6	7.3	3.6	2.7
	85.0	68.8	—2.1	35.8	69.6	76.2	6.6	10.5	51.9	66.3	29.5	—1.4	91.5	82.9	11.1	6.6
	66.3	51.9	—1.4	29.5	82.9	91.5	6.6	11.1								
16)	151.3	120.7	—3.5	65.3	152.5	167.7	13.2	21.6								
					167.7		21.6									
34)					320.2		34.8									
Res'lts	9.5	7.5	—0.2	4.1	9.4		1.0									

We then proceed in the same way with the plottings of the lunitidal intervals, reading ordinates and classifying for four positions of the moon in declination as follows, (see the specimens of these plottings, Sketch No. 29:)

Obs.	☾ Dec. N.				☾ Dec. 0				☾ Dec. S.				☾ Dec. 0			
	H. W.		L. W.		H. W.		L. W.		H. W.		L. W.		H. W.		L. W.	
	b	r	b	r	b	r	b	r	b	r	b	r	b	r	b	r
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
1867	12 32	13 24	19 33	18 57	12 12	12 21	18 33	18 28	13 47	12 39	18 57	19 47	12 33	12 21	18 39	18 52
	11 55	12 57	18 57	18 15	12 42	12 42	18 50	18 50	13 2	11 39	18 12	18 38	12 54	13 0	19 8	19 0
	11 30	12 24	18 10	17 50	13 1	12 57	19 4	19 24								
1855													12 55	12 57	19 22	18 48
	12 8	13 26	19 9	18 39	12 22	12 36	18 36	19 21	13 15	12 6	18 36	19 18	12 26	12 30	18 34	18 12
	12 40	13 51	19 32	18 57	12 24	12 20	18 3	18 32	13 57	12 28	18 57	19 39	12 12	12 12	18 24	18 9
	12 57	14 6	20 6	19 23	12 18	12 18	18 22	18 26	14 3	12 25	19 3	19 51	12 33	12 9	18 32	18 20
	12 36	14 14	19 50	18 48					13 33	12 6	18 42	19 30	12 45	12 52	18 57	18 58
	11 54	13 36	18 54	18 24	13 14	13 10	19 20	19 26								
1841													13 30	13 30	19 57	19 30
	11 12	12 38	18 15	17 48	13 4	13 10	19 0	19 8	12 42	11 24	17 46	18 18	12 27	11 48	18 27	18 3
	109 24	120 36	172 26	167 1	101 17	101 34	149 48	151 35	94 19	84 47	130 13	135 1	114 15	113 19	170 0	167 52
	84 47	94 19	135 1	130 13	113 19	114 15	167 52	170 0								
16)	194 11	214 55	307 27	297 14	214 36	215 49	317 40	321 35								
					215 49		321 35									
34)					430 25		639 15									
Res'lts	12 8	13 26	19 13	18 35	12 39		18 48									

We may now collect the results of these operations into a general statement like the following:

TIDES AT SITKA.

The two tides of the same day are generally unequal in proportion to the moon's declination. The time and height can be obtained approximately from the following table:

Moon's declination.	Moon's upper meridian passage.				Moon's lower meridian passage.			
	High water.		Low water.		High water.		Low water.	
	Interval.	Height.	Interval.	Height.	Interval.	Height.	Interval.	Height.
	h. m.	Ft.	h. m.	Ft.	h. m.	Ft.	h. m.	Ft.
Greatest north.....	12 8	9.5	19 13	— 0.2	13 26	7.5	18 35	4.1
Zero................	12 39	9.4	18 48	1.0	12 39	9.4	18 48	1.0
Greatest south.....	13 26	7.5	18 35	4.1	12 8	9.5	19 13	— 0.2

The interval is to be added to the time of the moon's meridian passage to give the time of high or low water. The time of the moon's upper meridian passage is given in the almanac, and the time of its lower meridian passage is the middle between two successive upper passages. The heights are given in feet and tenths, and show the rise above the level of the average of the lowest low waters, to which level the soundings on the chart are given.

SPRING TIDES.—At the full and change of the moon the high waters will be 1.1 feet higher than the above, and the low waters 1.1 feet lower.

NEAP TIDES.—At the moon's first and last quarters the high waters will be 1.1 feet lower, and the low waters will not fall as low by 1.1 feet.

APPENDIX No. 7.

MEMORANDA RELATING TO THE FIELD-WORK OF THE SECONDARY TRIANGULATION.

PREPARED BY RICHARD D. CUTTS, ASSISTANT.

Three orders of triangulation are recognized in the geodetic operations carried on for the survey of the coast:

I. The primary series, with sides varying from twenty to one hundred miles in length, such as those extending from the St. Croix to Cape Henry, and along an important part of the coast of California.

II. The secondary triangulation, with sides from five to twenty miles in length, either connected with the primary, or which, starting from independent bases, is being gradually extended over the coasts, sounds, and bays from Cape Henry to the Rio Grande.

III. The tertiary triangulation, with sides less than five miles, such as the short series which branch off from the secondary, and are carried up the smaller rivers and inlets of the sea.

SELECTION OF STATIONS.

A careful reconnaissance invariably precedes the selection of new points for the continuation of the geodetic work of the survey. The first step will be to decide upon the proportions of the scheme best adapted to the character of the country and for the success and progress of the work, and the next the reconnaissance in detail. In the case of high elevations and an open country, little difficulty will be encountered; but if the hills are densely wooded and tolerably uniform in height, the greatest care and skill are needed to select such intervisible points as are the most favorably situated, not merely for the extension of the triangulation, but to satisfy other conditions imposed by the survey. Should the land be uniformly low and clear, the triangulation may be laid off, as on paper, restricted only in its proportions by the curvature of the earth and the height to which the signal and instrument should be elevated; but if covered with forest or heavily-timbered swamp, the length of the lines will be governed by the labor and expense of opening them, taking into view the possibility of carrying on a smaller series of triangles immediately on the coast, or the alternative of opening additional lines to determine on the shore the detail points required for the surveying operations. In cases of this latter character, the obstacles to accuracy and to progress may be so great as to render it advisable that a direct measurement of the coast be started and continued until such difficult section has been passed.

If the reconnaissance covers any extended portion of the coast, and a scheme be adopted for the geodetic work, the question will arise whether the proposed triangulation, from its proportions, as determined by the character of the country, will need verification before joining on with the principal bases as measured in each section; and if so, at what intermediate points could such subsidiary lines and azimuths be measured and observed for the correction of the distances and directions.

In the performance of the above duty, the assistant will keep steadily in view the requirements alike of the triangulation and of the survey; and it will be his aim so to modify and adjust them, each in the ratio of its value, to the special features of the country under examination, as to produce a plan of triangulation which, while it satisfies the conditions prescribed, will be the most effective

in its results and economical in its execution. The most important of these requirements, beyond the paramount condition of the certain intervisibility of the stations intended to be connected, are:

I. The adoption of the highest elevations.

II. The maximum length of line consistent with the limit of 30° prescribed for the least size of an angle. A smaller angle is admissible in quadrilaterals, and also at one end of a base or known line, but not at any new point to be determined.

III. The forming of quadrilaterals.

IV. The modifications or changes which can be effected in the position of the proposed stations, so as to avoid, as much as possible, the labor and expense of opening lines through the forest or swamp.

V. The sweep of the horizon, or of the area to be surveyed, with a view to the easy determination of intermediate stations, and of light-houses, spires, chimneys, or other prominent objects not more than two or three miles apart, for the special use of the plane-table and hydrographical parties.

VI. The capacity of the station ground to be protected from the destructive effects of storms and waves, and from the ordinary pursuits of man, with a view to the preservation of the station for future use.

VII. The consideration of the altitude to which the theodolite must be raised to escape the variable refraction incident to the visual ray passing close to the surface of the ground.

The following table will be of use in the reconnaissance, and in arranging the height of the signal and observing tripod to be erected for long lines over water or level land. The line of sight from the telescope to the signal should never be allowed to pass less than six feet above the ground at the tangent point.

Difference in feet between the apparent and true level.

Distance, miles.	Difference in feet for—			Distance, miles.	Difference in feet for—		
	Curvature.	Refraction.	Curvature and refraction.		Curvature.	Refraction.	Curvature and refraction.
1	0.7	0.1	0.6	13	112.8	16.9	95.9
2	2.7	0.4	2.3	14	130.8	19.6	111.2
3	6.0	0.9	5.1	15	150.2	22.5	127.7
4	10.6	1.6	9.0	16	170.8	25.6	145.2
5	16.7	2.5	14.2	17	192.9	28.9	164.0
6	24.0	3.6	20.4	18	216.2	32.4	183.8
7	32.7	4.9	27.8	19	240.9	36.1	204.8
8	42.7	6.4	36.3	20	266.9	40.0	226.9
9	54.1	8.1	44.0	21	294.3	44.1	250.2
10	66.7	10.0	56.7	22	323.0	48.4	274.6
11	80.7	12.1	68.6	23	353.0	52.9	300.1
12	96.1	14.4	81.7	24	384.4	57.7	326.7

$$\text{Curvature} = \frac{\text{square of distance}}{\text{mean diameter of earth}} = \frac{\text{log. square of distance in feet}}{7.6209147}$$

Refraction $= \frac{K^2}{R} m$, where K represents the distance, R the mean radius of the earth, and m the co-efficient of refraction.

$$\text{Curvature and refraction} = (1\text{–}2\,m)\,\frac{K^2}{2R}.$$

Or, calling h the height in feet, and k the distance in statute miles, at which a line from the height h touches the horizon, taking into account terrestrial refraction, assumed to be of the same value as in the above table, (.075,) we have

$$k = \frac{10}{7.53}\sqrt{h} \qquad h = \frac{10}{17.63}k^2.$$

As an illustration of the use of the preceding table, let us suppose that a line, A to B, was 18 miles in length over a level plain, and that the instrument could be elevated at either station, by means of a portable tripod, to a height of 20, or 30, or 50 feet. If we determine upon 36.3 feet at A, the tangent would strike the curve at the distance represented by that height in the table, viz., 8 miles, leaving the curvature (decreased by the ordinary refraction) of 10 miles to be overcome. Opposite to 10 miles we find 56.7 feet, and a signal at that height erected at B would, under favorable refraction, be just visible from the top of the tripod at A, or be on the same apparent level. If we now add 8 feet to tripod and 8 feet to signal pole, the visual ray would certainly pass 6 feet above the tangent point, and 20 feet of the pole would be visible from A. Other variations may be made to suit the circumstances, as it rarely happens that in lines across water or level land there are not some slight elevations which could be made available as stations.

If it is desired to ascertain whether two points in the reconnaissance, estimated to be 44 miles apart, would be visible, one from the other, the natural elevations must be, at least, 274 feet above mean tide, or one 227 feet, and the other 327 feet, &c. This supposes that the intervening country is low, and that the ground at the tangent point is not above the mean surface of the sphere. If the height of the ground at this point should be 200 feet above mean tide, then the natural elevations should be 474, or 427 and 527 feet, &c., in height, and the line barely possible. To insure success, the theodolite must be elevated, and at both stations, to avoid high signals.

These are two extreme cases, and the nearest approach to non-visibility allowable on the work. It is always the interest of the assistant so to arrange the height of his signals and observing tripod as to have it in his power to observe on the lower part of the pole, and, consequently, for the longest period during the hours a. m. and p. m. assigned to horizontal angles.

NAMES OF STATIONS.

The station should be called after popular designation of the hill or site on which it is situated; or after some peculiarity in the ground or formation, well known in the neighborhood; or from the name of the owner or tenant of the land; or where neither owner nor distinctive traits are to be found, by such designation as, in the opinion of the assistant, will best serve to attract attention to the special locality. The same name should not occur twice within the same section of country. If it should be necessary to reoccupy the station and the centre cannot be positively identified, the fact should be stated, and the approximate position be designated as No. 2, or by the year of the reoccupation, as, for instance, Red Hill^2 or Red Hill^{69}. If the new position is merely in the vicinity of the old station, an entirely new name should be given to it.

SIGNALS.

The following signals are employed in the triangulation, according to circumstances:

I. The heliotrope carefully adjusted, on a stand or tripod, to the centre of station, and the pointing watched and attended to by an employé trained for the duty. This signal is used when long lines are to be observed, or those rendered difficult by haze, smoke, or other impurities in the atmosphere.

II. A reflector, such as the frustum of a tin cone, mounted on a stout pole, supported and retained in position by a tripod, and by wire guys, if advisable.

III. And in short lines, the simple pole supported by a tripod, the diameter of the pole being, in all cases, apportioned to the average distance to surrounding stations.

The height of the pole and dimensions of the tripod; the boarding of the upper and lower part, or the color of the pole, whether black or white, or with alternate bands of each, to insure prompt recognition; and the character of the mark, if any, centered on the top, to be used for identification, will vary with and depend upon the length of the line; the altitude of the station; the background of the signal as seen from the points of observation, and the atmospheric difficulties to be overcome. The marks used in long lines for identification are a tuft or keg, or other object not exceeding fifteen inches in diameter, and others which, in cases of emergency, can be observed upon, such as any article with a clearly defined central apex and within the preceding limit as to size.

In regard to the diameter of the pole to be observed upon, it is evident that, in short lines, it should not exceed the size just sufficient to admit of its being distinctly seen, as all beyond that is a source of error, arising from the additional range given to the bisecting thread. In the tertiary triangulation the diameter varies from two to five inches, and, in the secondary, from five to eight inches.

In the erection or use of any kind of signal no chance for an error in the determination of the angle should be allowed by a want of care and precision in centering the mark to be observed upon, exactly over the centre of the station. And should this source of error be at any time suspected an examination is promptly made, and if found to exist, the distance and direction of the point, or centre of the object actually observed upon from the centre of the true station, should be measured and recorded for the correction of the angles. See formula for eccentricity of signal.

In no case should the foot of the pole be inserted in or be allowed to come in contact with the earthenware cone, or other article buried as an underground mark. Six or eight inches of earth carefully packed above the cone or block, and upon this a square foot or so of board, upon which the pole can rest, will be sufficient to afford a foothold when such is necessary, and, at the same time, to prevent any displacement of or injury to the mark, in case the pole should be roughly handled or blown down.

TRIPODS AND SCAFFOLDS.

The tripod and scaffold, which are frequently erected for the elevation of the instrument and observer, in order to obtain a longer length of line or to escape the troubled condition of the atmosphere usually lying immediately over the low, flat lands bordering the coasts and shores, vary in height from 10 to 60 feet, and are made of scantling purchased for the purpose, or of materials obtained from the forest, and are built in general accordance with the plans and specifications given in the annual reports. While a strict adherence to uniformity in the details of the construction is not possible, so much depending upon the means and facilities at the disposal of the assistant and upon a proper regard to economy, the general principles of strength and solidity, in both tripod and scaffold, are strictly observed, by a proper spread and anchoring of the feet, a thorough bracing of the legs, and a compact fitting of the cap to the top of the tripod. A careful attention to these points will secure perfect immobility while the observations are being made, and sufficient firmness to keep the scaffold entirely and always free from contact with the tripod, and to enable both structures to resist the most violent storms.

The following description and plan of a small portable tripod and scaffold may be of service, the height being well adapted for short lines on the southern coast:

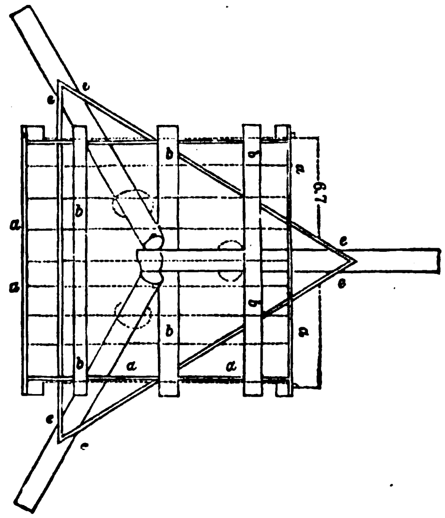
Tripod.—This is made of three legs 18 feet long and six inches in diameter, bolted together, 3 inches from the top, with an inch bolt, 16 inches long. After they are fitted together at the head, the spread being 13 feet, and before raising, one of the braces, *ee*, is screwed to the two outside legs so as to keep them in place while raising the tripod by the third leg. It is then settled two feet in the ground, care being taken to level it by the braces *ee*, which are to be screwed on with wooden screws.

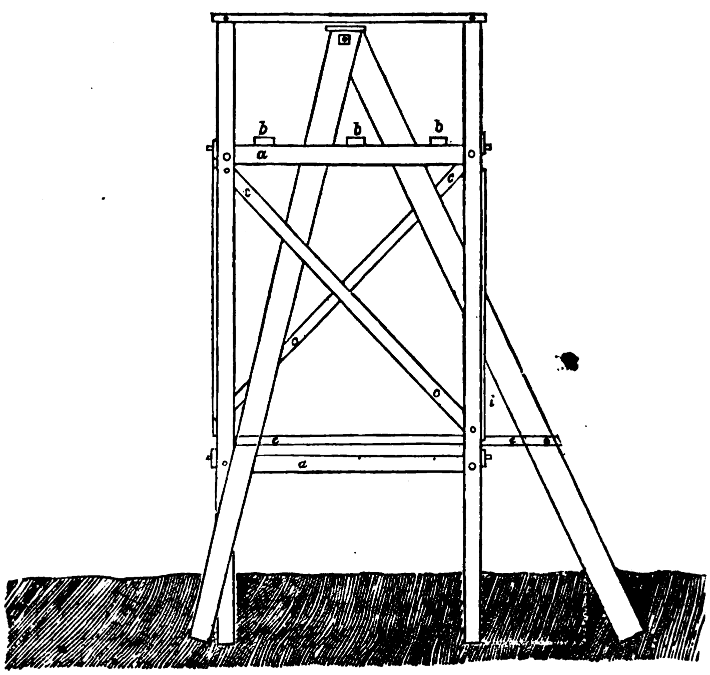
Scaffold.—4 posts, 16½ feet long and 5 inches square.
8 cross-pieces, 7 feet long and 6 inches by 1¼, *a a*.
3 cross-pieces, 7 feet long and 6 inches by 1, *b b*.
4 braces, 10 feet long and 5 inches by 1¼, *cc*.
8 flooring pieces, 7 feet 3 inches long and 9½ by 1, with holes for the tripod legs.

The end posts are those on which the braces and cross-pieces screw on the outside, and which are to be fastened together in pairs, when on the ground, so that it may be raised after the manner of a bedstead or house frame. The braces *cc* are to be bolted to the upper ends to steady the posts when raising them. All the holes in the posts, cross-pieces, and braces are to be identical as to plan and size, as also the pieces themselves, so as to have no mistakes, and when raised the scaffold fits to the tripod as shown in the drawing. The scaffold is levelled by the cross-pieces and adjusted, and in firm position after the floor is on, so as to be free from the tripod. The floor is to be 2 feet 10 inches below the top of the tripod. Three iron knees are screwed to the tripod legs

near the top, so that the triangular piece for the theodolite can be bolted to them. This piece is made of two pieces of one-inch plank screwed together across the grain, and then painted. Holes are made in the floor for the tent posts, and wire guys are sometimes required for the scaffold.

The above takes about two hours to put up. One large and two small wrenches are necessary; also a bag to contain the screws, nuts, &c. Should more than one be needed, they should be painted different colors, but be in all other respects exactly alike, in order that one can be used to repair the other.





THE UNDERGROUND STATION MARKS.

The station marks include the underground and surface marks; the former to be buried and the latter to be thrown up for the preservation of the centre and of the position of the station.

The essential requisites for an underground mark or one buried below the frost and plow line, and beyond the reach of ordinary accident or interference, say three feet, in the clear, below the surface, are: indestructibility, peculiarity, capacity to resist displacement in case it should be accidentally struck, cheapness, and, finally, want of value for any of the ordinary purposes of life, as a protection against cupidity. The following marks, partaking more or less of these essential qualities, have been adopted in the survey.

1. The frustum of a hollow stoneware cone, called the Hassler cone. The dimensions for primary stations are for the upper and lower diameters and the height 8, 12, and 15 inches, respectively.

2. One similar in shape to the preceding, but made of iron, and occasionally with a rim like that of a hat, encircling the larger diameter, upon which are inscribed in the casting the words "U. S. Coast Survey."

3. A hollow stoneware pyramid.

4. A short column of marble, granite or sandstone, manufactured for the purpose, and in some cases placed above the cone, the top reaching within six inches of the surface.

5. A block composed of brick or stones and hydraulic cement.

6. A bottle with three others just below the surface pointing to the lower one.

The centre of the station in the cone is either the centre of the periphery or the intersection of two lines drawn on the head of a copper tack driven in a stub placed and packed inside of cone, and sometimes extending within a foot of the surface; or, when a block is used, by the intersection of cross-lines on the head of a copper bolt inserted for the purpose. The initials U. S. C. S. are occasionally cut upon the block.

Of these and other varieties of underground marks which have been adopted at times from choice and again from necessity, the stoneware or iron cones are clearly to be preferred.

THE SURFACE STATION MARKS.

The surface marks are so varied in their character, and depend so much upon the nature of the ground, that no special rules can be established for their selection. What would be highly appropriate in one case would be equally inappropriate in another; and at many localities, such as those affected by the winds and waves and unavoidable as stations from the necessities of the work, no marks whatever can be arranged or erected with any hope of permanency, except at considerable expense. As the object of the surface marks is to secure the position and recognition of the station at any time hereafter, it is evident that the general principles which should govern in each case, to the full extent to which the locality will admit of their application, are, permanency or durability, facility with which they can be recognized, and the absence of value for any domestic or farm purpose. The following methods of marking have been employed in the survey:

1. A hole, an inch or two in diameter, drilled in the rock on which the signal stands, and filled with lead, sulphur, or a copper bolt.

2. In the case of earth, a stone block, pillar, or post, marking the centre of the station, and three others, two in line and one at right angles, equidistant from the centre.

3. A large rock rolled to centre and there sunk, or a block constructed of brick or stones and hydraulic cement, with the usual drilled hole and bolt of lead, copper, or sulphur.

4. An iron screw-pile, the centre being marked on the cap, and also on a stub inside of tube, the top of stub having been previously covered with a disc of copper sheeting, on which the initials of the survey and date are punctured.

5. Owing to the requirements of the survey, many of the stations are located on the immediate line of coast, or on the margin of the low shores of the Gulf and Southern sounds. When situated on a sand knoll or hill, the point is secured by a screw-pile, or a stone block packed in a box or framework of wood; and by the introduction, at and around the station point, of clay or marsh mud, or other foreign substance convenient to the locality, and the knoll protected from the moving effect of the wind by abattis, constructed of a circle, or circles of stakes intertwined with brushwood, an accumulation of sand being less objectionable than the denuding of the station marks.

6. Or, in case of a raised beach, subject to being washed away during a heavy gale, or by the slower action of the currents, beside the usual station marks, a point of reference is established back

from the shore line, and its relation to the centre of the station, determined by a careful measurement of the distance and azimuth between the two, so that the duplicate point may be used, or another established as an eccentric station, should such be needed at any time hereafter.

7. When the station is situated on the margin of a marsh, or a wooded swamp, it is secured by a screw-pile, or long pieces of scantling forced as far as possible into the yielding soil, and projecting two or three feet above the surface.

8. Beside the natural elevations occupied as stations, those of an artificial character have been made available whenever it was expedient to do so, such as light-houses, towers, steeples, houses, barns, &c. The centre of the station, when it can be marked, is designated, in the case of stone or cement, by the usual drilled hole and bolt; or, where metal is found, by a point within a triangle, both deeply engraved; or, in the case of wood, by a wooden pin driven in an auger-hole bored within a triangle cut, or formed by copper tacks, or by a piece of copper sheeting nailed to the wood and marked as above.

9. In addition to one or the other of the above marks, to be selected according to its special applicability to the case, the position is secured, whenever possible, by a circular trench, either left open or filled with charcoal or other substance foreign to the position, and then covered up, or by a mound of earth or pyramid of stones covering the surface marks.

10. By points of reference, such as measurements and magnetic courses, from the centre of the station to rocks in situ, stone walls, houses, trees, stumps, stakes in the prolongation of the lines to other stations, or to some prominent hill or building, and to other more or less permanent objects, artificial or natural. When the points referred to are within measuring distance, they should be designated by a triangle or other appropriate mark.

11. By a written description and topographical plan of the ground, its surroundings, and approaches, including the station marks, the points of reference, and the courses and distances thereto. The name of the owner or tenant of the land, and of the resident or neighbor who has been requested to take charge of the station, or of others who will know most about its position, should be given.

12. And, finally, at important stations, by views and sketches of the locality and its peculiarities, from different points, as a further means of identification.

The stone pillars or posts are from four to six inches square, and vary in length from twenty-four to thirty inches; the blocks or monuments, from eight to twenty-four inches square, and from eighteen to twenty in depth, and in all cases sunk nearly level with the ground. The usual cross-lines to define the actual centre are drawn on these as well as on the bolts, and the letters U. S. C. S. in some cases cut upon the stone.

The distance of the three surface marks, whether of stone or cedar, as referred to in No. 2, should be uniformly six feet from the centre of station, unless a different distance is unavoidable from the nature of the ground. Each should have an arrowhead on it, pointing to the centre of the station, and they should be placed North, South, and East, in order to facilitate the search, should one or two be covered up or lost. The distances and courses, however, are always given in the description of stations.

Too great care cannot be taken for the security and identification of the station.

THE OBSERVATIONS AND RECORDS.

Uniformity in conducting the field operations, and in the order in which the observations are recorded, should be strictly observed.

1. The number of the repeating theodolite, its size, and the order of its graduation, whether from left to right, or right to left, should be entered at the commencement of each volume.

2. The angles should be measured in the direction of the increasing numbers on the circle, so that, in all cases, the first reading may be subtracted from the second, and the station first pointed at should be the first named.

3. Whatever may be the number of repetitions of which each series may consist, those taken in the direct position of the telescope should be separated from those taken in the reversed position.

4. If the telescope cannot be reversed, except by being lifted from its supports, the verniers should be re-read after reversal.

5. In the determination of important angles, the pointings should be so arranged as to fall upon as many different parts of the circle as the proposed number of measurements will permit, with a view to eliminate any error of graduation or eccentricity.

6. When the angle measured is subject to a correction for phase, the direction of the sun and the time should be given, as well as the form and dimensions of the tin cone or other reflecting object observed upon.

7. The closing of the circle in the secondary triangulation, or the measurement of the angle between the last station and the first, should be made with the same care with which the regular angles were determined.

8. The observations should follow in the record in the order in which they were taken. The angle between the signal and sun for computing the correction for phase should follow the observations to which it belongs, and when the station is eccentric, the fact is mentioned at the top of the page, and the additional angle and distance required recorded in full.

Economy of pages or space in the record-book is of little consequence in comparison with irregularities in the record.

It would add to the completeness of the season's records if a plan of the triangulation executed should be attached to the first volume; and, also, if at the commencement of each station, the telescope, fixed at zero, should be pointed at the first station, and then, following the graduation, to the next, and so on to the starting point, completing the horizon and recording the reading in each case, so as to obtain the approximate value of the different angles to be measured.

The following abbreviations denoting the kind of signal observed upon, its appearance, &c., are those generally adopted in the survey. Too great detail in this matter is not considered necessary, having no weight in the computations; as in cases where the angle is really believed to be affected by the condition of the atmosphere in either magnifying, distorting, or giving too great motion to the signal, the observer will say so, and, after giving his reasons, will reject the observations; and if he does not, the computer is rarely, if ever, authorized to do so.

The record-book, for horizontal angles, is prepared with printed headings for the different columns, showing the order in which the details are to be entered.

ABBREVIATIONS.

Signal.		*Degree of Visibility.*	
Heliotrope	H.	Distinct	dt.
Cone	C.	Bright	br.
Pole	P.	Faint	ft.
Tuft	T.	Flaming	fl.
Crotch	Cr.	Diffuse	dif.
Steadiness.		*Weather.*	
Steady	st.	Clear	cl.
Tremulous	tr.	Flying Clouds	fy. cl.
Moving	mg.	Cloudy	cly.
Figure.		*Size.*	
Round	r.	Point	pt.
Oval	ov.	Small	sm.
Irregular	ir.	Large	lg.

NUMBER OF OBSERVATIONS.

The number of sets of repetitions required for the determination of any one angle must depend upon the value to be attached to the result. In the secondary triangulation in which the length of the sides varies from five to twenty miles, and especially in cases where such triangulation is the most extended which the nature of the country will admit of, and the results of which become in consequence of primary importance, the angle should be determined by not less than six sets, each consisting of six repetitions in the direct and six in the reversed position of the telescope, or twelve

sets of three in the D and three in the R. If the triangles belong to the tertiary series, the sides being five miles and under in length, the number of sets will vary from three to six, according to the distance along the coast over which the chain will extend before a verification can be effected by connection with a line of the secondary triangulation, or by the measurement of a subsidiary base. In this class of angles, each set is made up of three repetitions in the D and three in the R, in order to increase the number of separate results with a view to comparison and the elimination of error.

While a minimum number of measurements may be prescribed for each angle belonging to the two orders of triangulation referred to, the maximum must be left entirely to the judgment of the observer. In forming this judgment the elevation of the instrument; the differently refracting media through which the line of sight passes, as over alternate sections of land, marsh, and water; the lateral refraction incident to long lanes opened through the forest or swamp; the appearance of the signal and the condition of the atmosphere, will be taken into consideration, and the observer, from one cause or another, may deem it advisable to multiply his observations until he becomes satisfied that he has obtained the value of the angle, or until an apparently discordant result is neutralized or proved to be exceptional.

In the case of auxiliary points determined with a concluded angle, such as light-houses, spires, chimneys, &c., and others specially thrown in between the secondary and tertiary stations to facilitate the operations of the topographical and hydrographical parties, a single measurement of six repetitions, three in the D, and three in the R, will be sufficient. Care should be taken, however, that the unobserved angle should not greatly differ from 90°, and especially that each determination of this character should have its check or verification by a second determination from a different base.

THE LIMIT OF ERROR.

Assuming about 6″ to be the limit of error in triangles of the secondary order, and about 12″ in those of the tertiary series, it is certain that to secure the desired degree of accuracy the observer should give his careful attention, seriatim, to the following points:

1. To the diameter and centering of each of the signals to be observed upon.
2. To the stability of the stand or tripod on which the theodolite rests.
3. To the centering of the instrument, and to its adjustment for parallax, collimation and level.
4. To his personal comfort when observing, by having the eye and telescope at the same height when standing in a natural position, and by avoiding the necessity for any strain on the body or twist in the neck to look at any particular signal.
5. To the preservation of the levels while observing, and to a certain degree of rapidity in the pointing consistent with a clear and decided bisection of the signal.
6. To taking the different sets required for the determination of the angle, part on one day and part on another, or dividing them between the a. m. and p. m. periods for observing.
7. To declining to observe under any manifestly improper or doubtful condition of the atmosphere, as shown principally by the signals.

The observations taken on a day when the sky is entirely overcast from sunrise to sunset are the most reliable, and next in value are those taken during a calm afternoon when the sky is wholly clear. The a. m. observations made before the sun has dissipated the vapors of the night, or has quieted down the irregularities in the lower stratum of the atmosphere by an equalization of the temperature, are believed to be the most uncertain. These irregularities may be recognized by an unusual refraction or elevation of the signals above the horizon, beside the jumping, duplication, or distortion of the image, and the greater the vertical refraction, the greater will be the probability of a slight lateral deviation in the ray.

After the preceding precautions have been strictly observed and the prescribed number of measurements taken, the next step will be to examine the separate values of each angle with a view to ascertain the probable accuracy of the pointings.

Assuming that repeating theodolites of the highest character are employed, the probable error of any angle in the secondary triangulation should not exceed 0″.7 or 0″.8, and this result is generally attained when, in a series of not less than six separate sets, each of six repetitions in the

direct and six in the reversed position of the telescope, the difference between the highest and lowest of those values is from five to six seconds, and when the number is increased to twelve the difference between the extremes does not exceed about ten seconds.

The above differences are merely recommended as a general test to be applied to the observations before the assistant leaves the station. It is not improbable that after the prescribed number of sets has been taken a critical examination of the values, and of the circumstances under which they were obtained, will show that additional measurements are necessary or advisable. There are other errors beside those of pointing, which, notwithstanding every precaution, may largely increase the probable error of the resulting angle. The fact of an agreement among separate measurements is not a proof of having obtained the correct value of the angle unless those measurements were made under different conditions of the atmosphere, and during a. m. and p. m. to guard against an altogether one-sided refraction and illumination of the signal.

PROBABLE ERROR.

o, o^1, o^2, &c.=the observed values of the angle.

n=number of such values, or sets of repetitions.

x_0=their arithmetical mean.

Δ=differences between x_0 and o, o^1, &c.

Σ=symbol denoting sum.

ε=mean error.

r=probable error of any one of the observed values.

r_0=probable error of x_0.

$$\varepsilon=\sqrt{\frac{\Sigma\Delta^2}{n-1}} \qquad r=0.6745\sqrt{\frac{\Sigma\Delta^2}{n-1}} \qquad r_0=\frac{r}{\sqrt{n}}$$

o, o^1, o^2, &c.	x_0	Δ	Δ^2
° ′ ″	″	″	″
61 32 10.0	13.0	−3	9
12.0		−1	1
13.0		−0	0
16.0		+3	9
17.0		+4	16
10.0		−3	9
13.0		14	44

$n-1=5=$co. log 9.30103

$\Sigma\Delta^2=44$ 1.64345

0.94448

ε .... 0.47224= 2″.97

log 0.6745 .... 9.82898

r .... 0.30122=±2″.00

$\sqrt{6}$ 0.38908

r_0 .... 9.91214=±0″.82

o, o^1, o^2, &c.	x_0	Δ	Δ^2
° ′ ″	″		
45 44 22.0	23.5	−1.5	2.25
30.0		+6.5	42.25
24.2		+0.7	0.49
26.4		+2.9	8.41
18.5		−5.0	25.00
30.0		+6.5	42.25
20.6		−2.9	8.41
23.2		−0.3	0.09
25.0		+1.5	2.25
18.1		−5.4	29.16
25.0		+1.5	2.25
19.0		−4.5	20.25
23.5		39.2	183.06

$n-1=11=$co. log 8.95861

$\Sigma\Delta^2=183.06$ 2.26259

1.22120

ε .... 0.61060= 4″.08

log 0.6745 .... 9.82898

r .... 0.43958=±2″.75

$\sqrt{12}$ 0.53959

r_0 .... 9.89999=±0″.79

Or, using only the differences or residuals, according to the formulæ given by Schott, page 308, 1856, and without employing logarithms,

$$r = 0.845347 \frac{\Sigma\Delta}{\sqrt{n(n-1)}}, \text{ or } r = 0.84\frac{\Sigma\Delta}{n-1} \qquad r_0 = \frac{r}{\sqrt{n}}$$

1st example, as above. 2d example, as above.

$$r = 0.845\frac{14}{5.48} = 2''.15 \qquad r = 0.845\frac{39.2}{11.49} = 2''.88$$

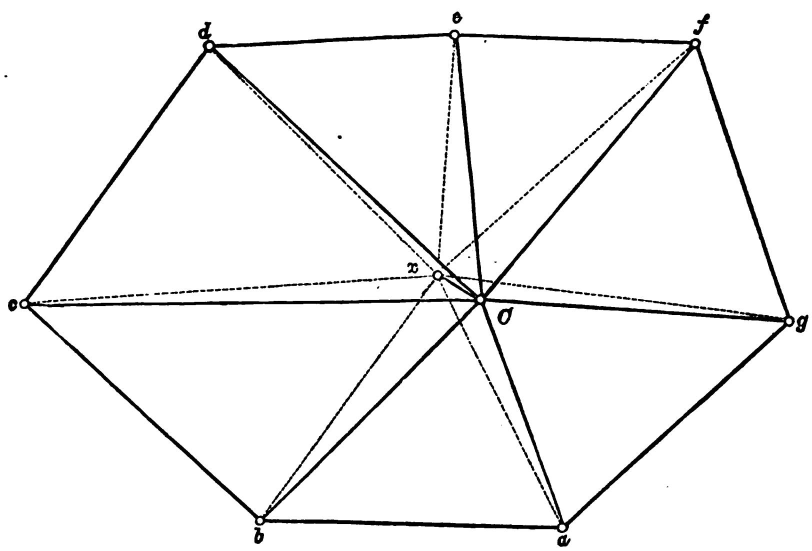
$$r_0 = \frac{2.15}{2.45} = 0''.88 \qquad r_0 = \frac{2.88}{3.46} = 0''.83$$

The number of measurements required for each angle having been taken, the next step will be to apply to each, or to their arithmetical mean, as the case may be, the corrections for phase, or eccentricity of the object observed upon, or those due to the occupation of an eccentric station. The angles in the abstract being corrected accordingly, if any such correction should be necessary, the final computation of the triangle sides will be commenced by computing the spherical excess, and by the distribution among the angles of the error found in the triangle.

The examples given in illustration of the following formulæ for reduction to centre of station, phase in tin cone, eccentricity of signal, and spherical excess, are believed to cover every possible case.

REDUCTION TO CENTRE OF STATION.

When the centre of the station cannot be occupied, the theodolite is adjusted at a point as close as possible to the centre, which new point is called the eccentric station. To be able to reduce the angles measured at the eccentric to the centre of the true station, it is necessary that the distance between the two should be measured with the utmost exactness, and that the angle at x, between the true centre and one of the stations of the triangle, be carefully determined.



C = centre of station.
x = eccentric position of instrument.
r = the distance Cx.
o = the angle at x between two signals, a and b.
y' = the angle at x between C and the left-hand signal a.
a = the distance Ca.
b = the distance Cb. sin 1″ = 4.6855749
C = the unknown angle at C. co. sin 1″ = 5.3144251

The signals are all supposed to be situated to the right of C, following each other in azimuthal order.

$$C = o + \frac{r \sin (o + y')}{b \sin 1''} - \frac{r \sin y'}{a \sin 1''}$$

The sign given for each term of the formula will be governed by that of the sine of $o + y$ and of y.

Example.—Triangle *axb.*

$r = \log 2^m.2145$	0.3452757	$r = 2^m.2145$	0.3452757
$\sin (o + y') = 89° 45' 20''$..	9.9999960 +	$\sin y' = 28° 29' 30''$.......	9.6785465 +
co. log b................	6.0855685	co. log a................	6.1870866
co. sin 1''................	5.3144251	co. sin 1''................	5.3144251
	1.7455653....+55''.66		1.5253339...—33''.52
	—33''.52		

$$C = 61° 15' 50'' + 22''.14 = 61° 16' 12''.14$$

Example.—Triangle *exg.*

$r = \log 2^m.2145$	0.3452757	$r = 2^m.2145$	0.3452757
$\sin (o + y^5) = 330° 20' 40''$.	9.6944163 —	$\sin y^5 = 236° 24' 15''$......	9.9206249 —
co. log g	6.0910863	co. log e................	6.1429692
co. log sin 1''	5.3144251	co. log sin 1''............	5.3144251
	1.4452034....—27''.87		1.7232949...+52''.88
	+52''.88		

$$C = 93° 56' 25'' + 25''.01 = 93° 56' 50''.01$$

When a large number of angles have been observed at an eccentric station, and different combinations are required, it is recommended that the directions to the different signals be arranged in the order of their azimuths, starting from the line xC, as shown in the following example, and that the correction for each line be computed by the formula

$$\frac{r \sin y^1}{a \sin 1''}$$

Angle.	Under 180°.	Over 180°.
$(o+y)$	+	−
y^1	−	+

By adding or subtracting the corrections for the two lines inclosing the special angle according to the signs given in this table, the reduction to the centre and its sign will be obtained. The direction to the right-hand signal always represents $(o + y)$.

Example.

	x to C 0° or 180°	x to a y^1	x to b y^2	x to c y^3	x to d y^4	x to e y^5	x to f y^6	x to g y^7
Direction	00° 00' 00''	28° 29' 30''	89° 45' 20''	139° 28' 40''	185° 32' 10''	236° 24' 15''	280° 14' 50''	330° 20' 40''
Sine		9. 67855	9. 99999	9. 81274	8. 98441	9. 92062	9. 99302	9. 69442
Log r		0. 34528	0. 34528	0. 34528	0. 34528	0. 34528	0. 34528	0. 34528
Co. log dist.		6. 18709	6. 08587	5. 92010	5. 99965	6. 14297	6. 04576	6. 09109
Co. sin 1''		5. 31443	5. 31443	5. 31443	5. 31443	5. 31443	5. 31443	5. 31443
		1. 52535	1. 74557	1. 39255	0. 64377	1. 72330	1. 69849	1. 44522
Correction		$a = 33''.52$	$b = 55''.66$	$c = 24''.69$	$d = 4''.40$	$e = 52''.88$	$f = 49''.94$	$g = 27''.88$

Hence, the corrections would be, for the angle between

	$''$ $''$		$°$ $'$ $''$ $''$ $°$ $'$ $''$
a and b	$=+55.66-33.52$	and C	$=$ 61 15 50 + 22.14 = 61 16 12.14
a " c	$=+24.69-33.52$	" C	$=$ 110 59 10 − 8.83 = 110 59 01.17
a " d	$=-\ 4.40-33.52$	" C	$=$ 157 02 40 − 37.92 = 157 02 02.08
c " e	$=-52.88-24.69$	" C	$=$ 96 55 35 − 77.57 = 96 54 17.43
f " g	$=-27.88+49.94$	" C	$=$ 50 05 50 + 22.06 = 50 06 12.06
g " a	$=+33.52+27.88$	" C	$=$ 58 08 50 + 61.40 = 58 09 51.40
f and a	$=+33.52+49.94$	and C	$=$ 108 14 40 + 83.46 = 108 16 03.46

The above eccentricity may be considered much greater than the average. Occasionally it is very small, as when, by some mistake, the instrument, mounted on a high tripod, cannot be adjusted exactly over the centre of station, but a few inches off, in one direction or the other. The distance and direction, in all cases, should be most carefully determined; and, if the eccentricity is large, the triangle sides, or distances, should be re-computed with the observed angles corrected by an approximate reduction to the centre.

CORRECTION FOR PHASE IN TIN CONES USED AS SIGNALS.

x = station of observer.
C = the sun; or, xC, the azimuth of sun.
y = angle between sun and reflecting cone.
a = distance between observer and cone.
r = mean radius of cone.

If the pointing is made on the bright reflecting line exhibited by the cone, then

$$\text{correction} = \pm\frac{r\cos\frac{1}{2}y}{a\sin 1''}$$

but if there is no such reflection, and the pointing be made on the white illuminated part of the cone,

$$\text{correction} = \pm\frac{r\cos^2\frac{1}{2}y}{a\sin 1''}$$

Examples.

Bright phase.

$r=0^{m}.215$	9.33244
$y=89°\ 40'$, cos $\frac{1}{2}$	9.85074
$a=18206^{m}$, co. log	5.73979
sin $1''$ co. log	5.31443
correction $=1''.72$	0.23740
$r=0^{m}.215$	9.33244
$y=176°$, cos $\frac{1}{2}$	8.54282
$a=18206^{m}$, co. log	5.73979
sin $1''$ co. log	5.31443
correction $=0''.08$	8.92948

White phase.

$r=0^{m}.215$	9.33244
$y=89°\ 40'$, cos $\frac{1}{2}$	9.85074
cos $\frac{1}{2}$	9.85074
$a=18206^{m}$, co. log	5.73979
sin $1''$ co. log	5.31443
$1''.22$	0.08814
$r=0^{m}.215$	9.33244
$y=176°$, cos $\frac{1}{2}$	8.54282
cos $\frac{1}{2}$	8.54282
$a=18206^{m}$, co. log	5.73979
sin $1''$ co. log	5.31443
$0''.003$	7.47230

The bright phase belongs exclusively to the curved cones usually employed as signals in the primary and secondary triangulation.

The line of reflection, or the illumination, is always on the same side with the sun. If, therefore, the direction to the second signal is on the same side of the reflecting cone as the sun, the correction is additive to the observed angle; if on the opposite side, subtractive. If both signals are reflecting, or illuminated cones, the difference between the two additive or subtractive corrections, as the case may be, is the correction to be applied ± to the angle.

The angle between the sun and the signal should be measured immediately after completing the set of repetitions to which the correction must be applied. Should the angle be omitted, but the time be recorded, the azimuth of the sun may be computed. It should be also matter of record whether the cone reflects or merely shows white.

CORRECTION FOR ECCENTRICITY OF SIGNAL.

C = centre of station.
x = the eccentric object, or part of signal observed upon.
r = the measured eccentricity.
a = the station of observer; also, the distance aC.

$$\text{Correction} = \pm \frac{r}{a \sin 1''}$$

Let us suppose, for example, that, during the occupation of the stations, a, b, c, and d, the pole at C was out of adjustment, or that x the object observed upon was not in the vertical of C, and that, to correct the error, the following measurements were made of the chord, or the perpendicular, from C to the different directions, viz: $0^m.155$, $0^m.293$, $0^m.182$, and $0^m.096$.

$r=0^m.155$, log..........	9.19033	$r=0^m.293$, log..........	9.46687
$a=6500^m$, log a sin 1''....	8.49849	$b=8206^m$, log b sin 1''......	8.59971
correction=4''.92.........	0.69185	correction=7''.36.........	0.86716
$r=0^m.182$, log..........	9.26007	$r=0^m.096$..............	8.98227
$c=12020^m$, log c sin 1''....	8.76548	$d=10008^m$, log d sin 1''....	8.68592
correction=3''.12.........	0.49459	correction=1''.98.........	0.29635

The diagram shows that in the triangles aCb, bCc, and cCd, the corrections to the observed angles should be

	''		''		''
for Cab.....	+4.92	Cbc.........	+7.36	Ccd.........	+3.12
for Cba......	—7.36	Ccb.........	—3.12	Cdc.........	+1.98

SPHERICAL EXCESS.

Every angle measured in the ordinary operations of geodesy is a spherical angle, and consequently the sum of the three observed angles of any triangle should, theoretically, exceed 180°. This spherical excess becomes appreciable only when the sides are from four to five miles in length; and being so small a quantity in proportion to the errors of observation, it is entirely overlooked in triangles of the third order.

In the secondary and primary triangulation, the spherical excess is applied to determine the error due directly to the observations. One-third of the computed excess is deducted from each angle of the triangle, and the difference between the resulting sum of the angles and 180° is the error to be distributed.

Let a, b = triangle sides.
C = the included angle.
A = equatorial radius..............$6377397^m.16$, log = 6.8046435
B = polar radius..................$6356078^m.96$, log = 6.8031893
e = the eccentricity $= \sqrt{1 - \frac{B^2}{A^2}}$
$e^2 = 0.006674372$..............................log = 7.8244104
L = mean latitude of the three stations.

$$\epsilon = \frac{ab \sin C\,(1 + e^2 \cos 2L)}{2A^2 \sin 1''}, \text{ and making } m = \frac{1 + e^2 \cos 2L}{2A^2 \sin 1''},$$

we have $\epsilon = ab \sin C\, m$.

The latitude being the only variable quantity in the formula m, we make the latter a constant by computing it for every 30' of latitude likely to be embraced in the survey, and tabulate the results. The value of m for intermediate latitudes may be taken out by inspection, though such precision is only necessary in the very largest triangles.

Computation of m.

$L=24^{\circ}$, $2\ L=48^{\circ}$, $\cos=9.8255109$
e^2, $\log=7.8244104$

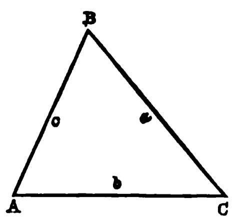
$\log e^2 \cos 2\ L=7.6499213$
$e^2 \cos 2\ L=0.0044603$
$1+e^2 \cos 2\ L=1.0044603$
$\log 1+e^2 \cos 2\ L=0.0019351$
$\log 2\ A^2 \sin 1''=8.5958918$

m for lat. $24^{\circ}=1.4060433$

$\sin 1''$	4.6855749
$\log A^2$	3.6092869
$\log 2$	0.3010300
$\log 2\ A^2 \sin 1''$	8.5958918

Latitude.	log m.	Latitude.	log m.	Latitude.	log m.	Latitude.	log m.
24° 00′	1. 40604	31° 30′	1. 40542	39° 00′	1. 40471	46° 30′	1. 40396
30	600	32 00	538	30	466	47 00	391
25 00	597	30	533	40 00	461	30	386
30	593	33 00	529	30	456	48 00	381
26 00	589	30	524	41 00	451	30	376
30	585	34 00	519	30	446	49 00	371
27 00	581	30	515	42 00	441	30	366
30	577	35 00	510	30	436	50 00	361
28 00	573	30	505	43 00	431	30	356
30	569	36 00	500	30	426	51 00	351
29 00	564	30	496	44 00	421	30	346
30	560	37 00	491	30	416	52 00	341
30 00	556	30	486	45 00	411	30	336
30	551	38 00	481	30	406	53 00	331
31 00	1. 40547	30	1. 40476	46 00	1. 40401	30	1. 40326

Example.

Denomination.		Observed angles.	Correction.	Spherical angles.	Spherical excess.	Plane angles and distances.	Logarithms.
		Preliminary comp. 3*ry* Δ	....	....	a	6500^{m}.	3. 81291
	A	75° 20′ 40″	....	....	0	....	0. 01437
	B	43° 23′ 30″	....	....	0	....	9. 83695
	C	61° 15′ 50″	....	....	0	....	9. 94292
					b=A to C	4615^{m}.6	3. 66423
					c=A to B	5891^{m}.2	3, 77020
		Preliminary comp. 1*ry* Δ	....	....	a	122755^{m}.	5. 08904
A		80° 22′ 10″	....	....	7″.539	....	0. 00614
B		49° 27′ 30″	....	....	7″.539	....	9. 86078
C		50° 10′ 20″	....	....	7″.539	....	9. 88535
					b=A to C	94615^{m}.	4. 97596
					c=A to B	95616^{m}.	4. 98053

Computation of spherical excess.

$a=6500^{m}$, log	3.81291	$a=122755^{m}$, log	5.08904
$b=4615^{m}.6$, log	3.66423	$b=94616^{m}$, log	4.97596
C $=61^{\circ}\ 15'\ 50''$, log sin	9.94292	C $=50^{\circ}\ 10'\ 20''$, log sin	9.88535
m for 36° L., log	1.40500	m for 45° 15′ L., log	1.40408
$\varepsilon=0''.067$	8.82506	$\varepsilon=22''.617$	1.35443

DISTRIBUTION OF ERROR.

In the primary series the errors are adjusted by the application of the method of least squares, as explained and exemplified in appendices Nos. 33 and 14, Annual Reports for 1854 and 1864; or distributed in proportion to the probable error of each angle as determined directly from the measures of the angles.

In the secondary triangulation the error is distributed as above, or in inverse proportion to the number of measures taken of each angle, or, in less important cases, equally among the three angles.

In triangles of the third order the error, as a rule, is equally distributed among the three angles.

Example.

Denomination.	Sets of repetitions.	Observed angles.	Correction.	Spherical angles.	Spherical excess.	Plane angles and distances.	Logarithms.
		a........	....	....	....	27370m.5	4.4372827
		° ′ ″		″		° ′ ″	
A	10	48 34 16.5	+ 1.4	17.9	— 0.6	48 34 17.3	0.1250650
B	7	86 12 10.6	+ 2.0	12.6	— 0.6	86 12 12.0	9.9990458
C	12	45 13 30.2	+ 1.1	31.3	— 0.6	45 13 30.7	9.8511853
		57.3					
		Sp. excess 1.8			A to C	36424m.49	4.5613935
					A to B	25913m.91	4.4135330
		55.5					
		Error 4.5					

L. M. Z.

The formulæ, tables, and examples for the computation of the geodetic latitudes, longitudes, and azimuths, are given and fully explained in appendix No. 36, Annual Report for 1860.

For the sake of easy reference during the rapid and numerous computations of this character required from the assistant in the field, the signs, and their application, of the corrections depending on the relation of the given azimuth to the different quadrants, and on the algebraic signs of dL and dZ, are tabulated as follows:

Corrections to given Latitude.	
Z = 0° to 90° Z = 270 to 360 dL subtractive from L.	Z = 90° to 180° Z = 180 to 270 dL additive to L.
″ + 1853.590 + 22.760 + 0.084 — 0.268	″ — 448.308 + .051 + .005 — .000
—dL = + 1856.166	—dL = — 448.252

Corrections to given Longitude.
Z = 0° to 90° Z = 90 to 180 dM additive to M.
Z = 180° to 270° Z = 270 to 360 dM subtractive from M.

Corrections to given Azimuth.
Z = 0° to 90° Z = 90 to 180 dZ subtractive from Z.
Z = 180° to 270° Z = 270 to 360 dZ additive to Z.

TRIGONOMETRICAL LEVELLING.

When vertical observations are taken the height of the telescope above the ground at each of the stations occupied, and of all the signals or objects observed upon, should be carefully measured and duly entered in the record.

Reciprocal zenith distances measured at any two stations at the same moment of time, or under the same supposed condition of the atmosphere, give the best results. When reciprocal, but not simultaneous, the observations should be made on different days, as in the case of horizontal angles, in order to obtain, as far as possible, a mean value of the difference between the respective angles, and an average value of the refraction. The same care should be taken when the zenith distance is measured at one station only.

Experience has proved that the refraction is greater and more variable at sunrise than at any other hour of the day; that it gradually diminishes, in both respects, until 9 or 10 a. m.; that

between those hours and 4 p. m. it is comparatively stationary, and from 4 p. m. to sunset it increases in amount and variation, being the greatest during the night. The best period for observing, therefore, is between 9 a. m. and 4 p. m., and the worst at sunrise and sunset.

The condition of the atmosphere and the relative refraction may be so different at stations situated more than twenty miles apart, that, as a general rule, the difference of level determined even by reciprocal observations cannot be relied upon for the desired degree of accuracy at distances greater than about twenty miles, unless a very large number of measurements have been made under the most favorable circumstances. The higher the elevations the more reliable the results.

When a station is occupied for vertical observations the zenith distance of every signal in sight should be measured, so as to have more than one check for each altitude. A number of such measures and differences of level should be so combined, by the method of least squares, as to give the most probable values for the respective altitudes, as well as for the coefficient of refraction for the period of observation.

I.—*By reciprocal zenith distances, simultaneous or not.*

Let Z, Z' = the measured zenith distances of the telescopes at the two stations.
K = distance, in metres, between the two stations.
R = radius of curvature of the arc joining the two stations.
C = angle at the earth's centre, subtended by the arc.
h, h' = heights of the two stations above mean tide.

$$C = \frac{K}{R \sin 1''} \qquad\qquad h - h' = \frac{K \sin \frac{1}{2}(Z' - Z)}{\cos \frac{1}{2}(Z' - Z + C)}$$

If the telescope is not observed upon, but some other object, such as the heliotrope or top of crotch, the measured zenith distance must be reduced to the telescope by the formula reduction $= \pm \frac{r}{K \sin 1''}$, in which r represents the height of the object, above or below the telescope.

The value of R, or of $\frac{1}{R \sin 1''}$, (which depends on the mean latitude of the two stations and the angle made by the arc with the meridian,) may be computed for different latitudes, and for angles varying from 0° to 90°, as in the following table:

Angle.	Latitude 25°.		Latitude 30°.		Latitude 35°.	
	log R	co. l. R sin 1″	log R	co. l. R sin 1″	log R	co. l. R sin 1″
° 0	6.802512	8.511913	6.802823	8.511602	6.803167	8.511258
10	2584	11841	2888	11537	3226	11199
20	2791	11634	3078	11347	3395	11030
30	3109	11316	3368	11057	3655	10770
40	3498	10927	3724	10701	3973	10452
50	3913	10512	4103	10322	4312	10113
60	4304	10121	4459	09966	4632	09793
70	4622	09803	4750	09675	4892	09533
80	4830	09595	4940	09485	5062	09363
90	6.804902	8.509523	6.805006	8.509419	6.805121	8.509304

Angle.	Latitude 40°.		Latitude 45°.		Latitude 50°.	
	log R	co. l. R sin 1″	log R	co. l. R sin 1″	log R	co. l. R sin 1″
° 0	6.803534	8.510891	6.803913	8.510512	6.804292	8.510133
10	3586	10839	3957	10468	4328	10097
20	3734	10691	4083	10342	4432	09993
30	3961	10464	4276	10149	4592	09833
40	4239	10186	4514	09911	4789	09640
50	4536	09889	4767	09658	4998	09426
60	4815	09610	5005	09420	5194	09231
70	5043	09382	5197	09228	5355	09070
80	5191	09234	5325	09100	5459	08966
90	6.805243	8.509182	5369	8.509056	5496	8.508929

Example.

K = 23931^m.6 ...... distance between two stations, Santa Cruz and Mt. Bache, California.
Z = 87° 34′ 34″.6 .. observed at Santa Cruz station, upon top of pole at Mt. Bache.
Z′ = 92° 34′ 57″.4 .. observed at Mt. Bache, upon top of pole at Santa Cruz station.
L = 37° 02′ .... mean latitude of the two stations.
angle = 51° 55′ .... angle made by line with the meridian.

Reduction to level of telescopes.

	m		m
Mt. Bache—top of pole above ground ..	4.72	Santa Cruz—top of pole above ground	5.77
Mt. Bache—telescope above ground ...	1.65	Santa Cruz—telescope above ground.	1.50
	r = + 3.07		r = + 4.27
r = 3.07	0.48713	r = 4.27	0.63043
co. log K	5.62103	co. log K	5.62103
co. sin 1″	5.31443	co. sin 1″	5.31443
	1.42259		1.56589
reduction to telescope	+ 26″.46	reduction to telescope	+ 36″.80
	° ′ ″		° ′ ″
observed Z	87 34 34.60	observed Z′	92 34 57.40
Z	87 35 01.06	Z′	92 35 34.20

Computation of h—h′.

			° ′ ″		
log K	4.3790	Z′—Z	5 00 33.14	log K	4.3790
co. log R sin 1″ ..	8.5101	½ (Z′—Z)	2 30 16.57	sin ½ (Z′—Z)	8.6405
		Z′—Z+C	5 13 28.06	co. log cos ½ (Z′—Z+C)	0.0004
log C	2.8891	½ (Z′—Z+C) ..	2 36 44.03		
C	774.56				3.0199

	m
Difference in height of telescopes	1046.90
Telescope at Mt. Bache higher than that at Santa Cruz	—0.15
Difference in height of ground	1046.75
Santa Cruz station above mean tide—by spirit level	108.87
Mt. Bache above mean tide	1155.62

II.—*By the zenith distance measured at one station.*

Let Z = the measured zenith distance of the signal or object.
K = the distance between the two stations, in metres.
m = the coefficient of refraction.

$$C = \frac{K}{R \sin 1''}$$

dh = difference in height between the two stations.

$$dh = \frac{K \cos (Z + mC - \frac{1}{2} C)}{\sin (Z + mC - C)}$$

Example.

Z = 87° 07′ 18″.8 ...... observed at Farmington upon crotch at Mt. Blue.
K = 15519^m .... distance between Farmington and Mt. Blue.
m = 0.071 .... coefficient of refraction.
L = 44° 42′ .... mean latitude of the two stations.
angle = 65° 44′ .... angle made by line with meridian.
Telescope above ground = 2^m.2 Crotch above ground = 4^m.4

						° ′ ″			
log K.....	4.1907	C........	501″.2	Z+mC......		87 07 54.4	log K.....	4.19086	
table......	8.5093	m........	0″.071	Z+mC—½ C.		87 03 43.8	cos.......	8.70971	
	———	mC.......	35″.6	Z+mC—C...		86 59 33.2	co. sin....	0.00060	
log C......	2.7000							———	
								2.90117	

$d\,h$—between telescope and crotch........	$\overset{m}{796.47}$
Telescope above ground........	+2.20
Crotch above ground........	—4.40
$d\,h$—between ground at Farmington and Mt. Blue........	794.27
Ground at Farmington above mean tide........	181.20
Ground at Mt. Blue above mean tide........	975.47

III.—*By the observed zenith distance of the sea horizon.*

Z = the measured zenith distance.
R = radius of curvature of arc.
m = coefficient of refraction = 0.078.

$$h = \frac{R}{2(1-m)^2} \tan^2 (Z - 90°)$$

Example.

Z = 90° 24′ 19″.1			Telescope above ground.........	$\overset{m}{1.67}$
L = 41° 15′			State of tide—below half-tide.........	0.30
angle = 15°				
R = 6.8038 from table.				
$(1-m)=(1-0.078)=0.922$, log²	9.92946			
log 2	0.30103			
	———	log R....	6.8038	
$2(1-m)^2$........	0.23049	....	0.2305	
$\frac{R}{2(1-m)^2}$........			6.5733	
(Z—90°) = 24′ 19″, tang²........			5.6994	
			2.2727	
$d\,h$—between telescope and sea horizon........			$\overset{m}{187.37}$	
Telescope above ground........			—1.67	
Reduction for state of tide........			—0.30	
Height of station above mean tide........			185.40	

IV—*By observed angles of elevation or depression.*

A = the observed angle, expressed in seconds.
K = the distance, in metres, between the two stations.
constant = 0.00000485 = log 4.68574
constant = 0.0000000667 = log 2.82413.

$$d\,h = 0.00000485\ K\ A \pm 0.0000000667\ K^2$$

This formula gives the difference in height between stations not more than ten or fifteen miles apart, with a probable error less than the uncertainty in the coefficient of refraction.

Example.

$A = 2^\circ\ 52'\ 41''.2 = 10361''.2 =$ angle of elevation.
$K = 15519^{m} =$ distance between the two stations.

log A	4.01541			
log K	4.19086		log K²	8.38172
constant	4.68574		constant	2.82413
	2.89201	.... 779.85ᵐ		1.20585 .... 16.06ᵐ
		16.06		
		$dh = 795.91$		

THE COEFFICIENT OF REFRACTION.

The coefficient of refraction, or proportion of the intercepted arc, is determined from the observed zenith distances of two stations, the relative altitudes of which have been determined by the spirit-level; or, from reciprocal zenith distances, simultaneous or not, under the assumption that the mean of a number of observations taken under favorable conditions will eliminate the difference of refraction which is found to exist, even at the same moment, at two stations a few miles apart. Such a co-efficient may be established for the level of the sea, or for high elevations, or for lines over water or over land. As, however, the difference of height, deduced from trigonometrical levelling, depends upon the coefficient multiplied by the square of the distance, it is evident that the longer the line, the greater would be the error caused by any uncertainty in the coefficient or actual refraction, and that, consequently, there is a limit to the distance for which any assumed mean value of the refraction can be depended on for accurate results.

The average value of the coefficient from the Coast Survey observations in the New England States, is,

between primary stations	0.071
of small elevations	0.075
of the sea horizon	0.078

To determine the coefficient of refraction from reciprocal zenith distances.

$C =$ angle at earth's centre subtended by arc.
$F =$ angle of refraction.
$m =$ coefficient of refraction.

$$C = \frac{K}{R \sin 1''} \qquad F = \frac{C}{2} - \tfrac{1}{2}(Z' + Z - 180^\circ) \qquad m = \frac{F}{C}$$

Example.

Adopting the observations and corrections in the example to I, and leaving out, as in that case, the very small corrections depending on the height of the stations above the mean surface of the sphere, we have,

	′ ″		
$Z + Z' - 180^\circ$	10 35.26	log F, 69.7″	1.8432328
$\frac{1}{2}(Z + Z' - 180^\circ)$	5 17.63	log C, 774.66	2.8891111
$\frac{C}{2}$	6 27.33	$m = 0.089975$	8.9541217
F	1 09.70		

To determine the coefficient from the zenith distance observed at one station, when the altitudes of the two stations above half-tide, or their difference in height, have been determined by the levelling instrument.

Compute the true zenith distances, Z'_o and Z_o, of the two given points, and the difference between the true and the observed zenith distance will be the angle of refraction, F; and $m = \frac{F}{C}$

$$\tfrac{1}{2}(Z'_o + Z_o) = 90^\circ + \frac{C}{2}$$

$$\tfrac{1}{2}(Z'_o - Z_o) = \tan^{-1}\left(\frac{h' - h}{K}\left\{1 - \frac{h' + h}{2R} - \frac{K^2}{12R^2}\right\}\right)$$

Example.

Adopting the data afforded by the example to II, we have,

$h'+h=975^{m}.47$, supposed to be determined by levelling instrument.

$h'-h=794^{m}.27$, supposed to be determined by levelling instrument.

Z = observed Z. D. + correction for height of crotch above telescope.

$Z=87^\circ\ 07'\ 18''.8+29''.2=87^\circ\ 07'\ 48''$

$K=15519^{m}=\log 4.1908637$

$C=501''.2=8'\ 21''.2$; and $\frac{C}{2}=4'\ 10''.6$

$R^2=3.6102$	$K^2=8.3817$	
$12=1.0792$	4.6894	
4.6894	$3.6923=-0.00000049$	
$R=6.8051$	$h'+h=2.9892$	
$2=0.3010$	$2\,R=7.1061$	
7.1061	$5.8831=-0.00007641$	$h'-h=2.8999682$
		$K=4.1908637$
	-0.00007690	
	0.99992310	$\frac{h'-h}{K}=8.7091045$
	log 9.9999666	$\left(1-\frac{h'+h}{2\,R}-\frac{K^2}{12\,R^2}\right)=9.9999666$
		$\tan=8.7090711$
		$2^\circ\ 55'\ 46''.7$

$$\tfrac{1}{2}(Z'_0+Z_0)=90^\circ+4'\ 10''.6=90^\circ\ 04'\ 10''.6$$
$$\tfrac{1}{2}(Z'_0-Z_0)=2^\circ\ 55'\ 46''.7$$
$$\text{true } Z'_0=92\ 59\ 57.3$$
$$\text{true } Z_0=87\ 08\ 23.9$$
$$\text{observed } Z=87\ 07\ 48.0$$

$F=$	35.9	........log=1.5550944
$C=$	501.2	........log=2.7000111
$m=\frac{F}{C}=$	0.0716	........log=8.8550833

THE THREE-POINT PROBLEM.

If three points, forming a triangle of which the sides and angles are known, or can be computed, be visible from a fourth point P, it is required to determine the position of P.

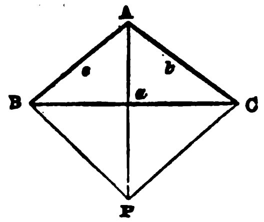
Set up the theodolite at P, and measure the two angles subtended by any two of the given sides.

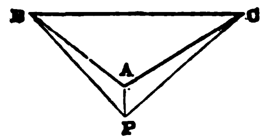
This problem is of use in cases where the regular triangulation having been completed, additional points are required for the topographical survey, or are needed for special service. The angles should be carefully measured, and, in the computations, the logarithms should be carried to seven places of decimals.

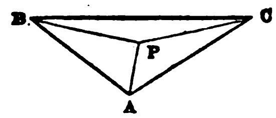
Three cases of its application are given, as in others, such as when P falls upon one or the other of the sides of the known triangle, or on the prolongation of either, the case resolves itself into the solution of a simple triangle with one side and the angles given; or the problem is indeterminate, as when P is situated on the circumference of the circle passing through the three known points—a contingency which rarely occurs.

Example for each of the three cases.

Given the side $a=11204.5$		Angle observed	$APC=P'$.
Given the side $b=7289.0$		Angle observed	$APB=P''$
Given the side $c=6273.8$		To find	$ABP=x$
Given the angle $A=111^\circ\ 10'\ 54''$		To find	$ACP=y$







P′....	50° 06′ 12″	P′..........	49° 47′ 20″	P′....	104° 00′ 00″
P″....	43° 50′ 38″	P″..........	44° 09′ 30″	P″....	100° 20′ 00″
S.....	$180° - \frac{1}{2}(A+P'+P'')$	S...........	$\frac{1}{2}(A-P'-P'')$	S.....	$180° - \frac{1}{2}(A+P'+P'')$
S.....	77° 26′ 08″	S...........	8° 37′ 02″	S.....	22° 14′ 33″

$$\tan Z = \frac{c \sin P'}{b \sin P''} \qquad \epsilon = \tfrac{1}{2}(x-y) \qquad \tan \epsilon = \cot(Z+45°) \tan S$$

$x = S+\epsilon$, $y = S-\epsilon$, but if $\tan \epsilon$ be negative, then $x = S-\epsilon$, $y = S+\epsilon$

Computation.

log c	3.7975307	log c	3.7975397	log c	3.7975307
sin P′	9.8849100	sin P′	9.8829061	sin P′	9.9869041
co. log b	6.1373320	co. log b	6.1373320	co. log b	6.1373320
co. sin P″	0.1594574	co. sin P″	0.1569894	co. sin P″	0.0071016
tan Z	9.9792301	tan Z	9.9747583	tan Z	9.9288684
Z	43° 37′ 49″.6	Z	43° 20′ 09″.2	Z	40° 19′ 43″.3
cot (Z+45°)	8.3785397	cot (Z+45°)	8.4631818	cot (Z+45°)	8.9122794
tan S	0.6519386	tan S	9.1805366	tan S	9.6116787
tan ϵ	9.0304783	tan ϵ	7.6437184	tan ϵ	8.5239581
ϵ	6° 07′ 21″.7	ϵ	0° 15′ 08″.1	ϵ	1° 54′ 50″.04
S	77° 26′ 08″.0	S	8° 37′ 02″.0	S	22° 14′ 33″.00
x	83° 33′ 29″.7	x	8° 52′ 10″.1	x	24° 09′ 23″.00
y	71° 18′ 46″.3	y	8° 21′ 53″.9	y	20° 19′ 43″.00
Hence,		Hence,		Hence,	
PAB	52° 35′ 52″.3	PAB	126° 58′ 19″.9	PAB	55° 30′ 37″.00
PAC	58° 35′ 01″.7	PAC	121° 50′ 46″.1	PAC	55° 40′ 17″.00

As all the angles and a side in each triangle are now known, the other sides, or the distances from P to the three given points, can be readily computed.

	m		m		m
PB	7194.87	PB	7194.94	PB	5256.29
PA	8999.89	PA	1388.54	PA	2609.75
PC	8107.98	PC	8107.91	PC	6203.63
PA	8999.89	PA	1388.54	PA	2609.75

The results are verified when both triangles give the same value for the line P A.

For the problem and an example by Schott, of determining a position by angles observed upon a number of given stations, see page 116, 1864.

RECTANGULAR CO-ORDINATES ON A PLANE PROJECTION.

The method of plotting the position of trigonometrical points by rectangular co-ordinates is occasionally adopted in the field, and consists in referring the points of the triangulation to two straight lines, intersecting each other at right angles, called the co-ordinate axes. If O be the point of intersection, or origin of the axes, then y will be the axis of ordinates, x the axis of abscissa, and Aa, Oa, or y, x, the rectangular co-ordinates of a given point A.

Should the true meridian be known, let that be the axis of ordinates, and the point of intersection a trigonometrical point; if not known, adopt, as the axis of abscissa, a side of one of the triangles, which, if extended in one or both directions, would pass through the centre of the triangulation, or as near thereto as possible. The triangulation point at one or the other end of this line, as may be preferred, will be, therefore, the origin of ordinates. Whatever may be the direction of the line, assume it, for the present purpose, to be a meridian, and count the azimuths from south to west, as in the L, M, Z computations.

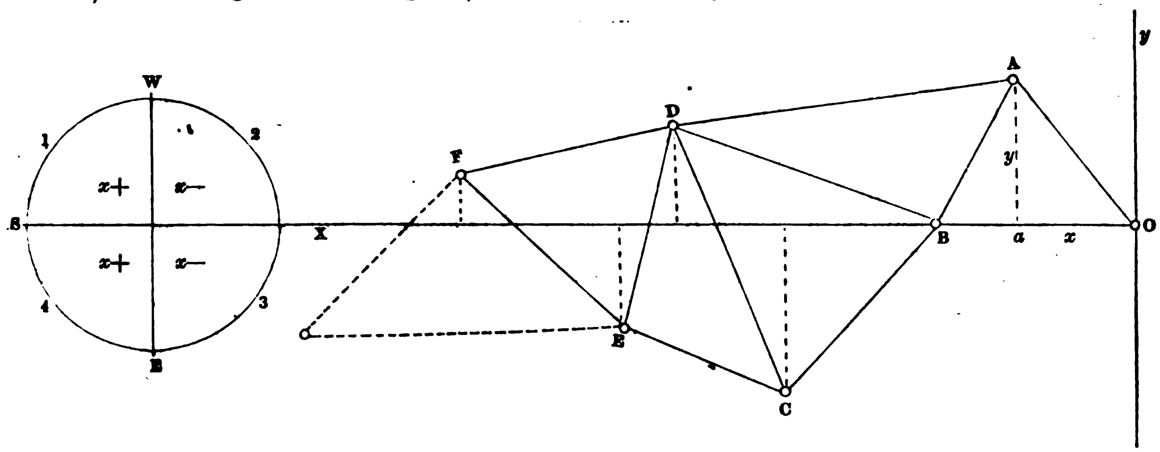
The values of the rectangular co-ordinates, y and x, are obtained by multiplying the triangle side by the sine and cosine of its azimuth.

The abscissa, x, will be additive when the azimuth is in the first and fourth quadrants, and subtractive when in the second and third.

The computed ordinate y will be subtractive from or additive to the last ordinate, according as the azimuth converges to, or diverges from, the axis of abscissa.

If the ordinates on one side of the axis of abscissa be regarded as positive, those on the other side will be negative.

Should the line adopted pass through the chain of triangles, as in the following example, having trigonometrical points on both sides, compute the rectangular co-ordinates for the points on one side, and then for those on the other, and the computation will be verified when the sum of the abscissa, on reaching the terminal point, shall be the same by both series.



	Denomination.	Plane angles and distances.	Logarithms.		Denomination.	Plane angles and distances.	Logarithms.
	O to B	5073m.68	3.7053234		D to C		3.8889246
A	Three Sisters	65° 27′ 55″.3	0.0410968	E	Persimmon Point	99° 38′ 59″.1	0.0061888
O	North End	51° 30′ 37″.9	9.8936078	D	South Base	36° 00′ 15″.2	9.7692627
B	Ragged Island	63° 01′ 26″.8	9.9499740	C	Coffee's Point	44° 20′ 45″.7	9.8444710
	A to B	4365m.44	3.6400280		E to C	4617m.17	3.6643761
	A to O	4970m.43	3.6963942		E to D	5490m.15	3.7395844
	A to B		3.6400280		D to E		3.7395844
D	South Base	28° 29′ 34″.2	0.3214372	F	North Base	53° 57′ 19″.6	0.0922879
A	Three Sisters	53° 19′ 39″.9	9.9042095	D	South Base	64° 48′ 09″.9	9.9565754
B	Ragged Island	98° 10′ 45″.9	9.9955595	E	Persimmon Point	61° 14′ 30″.5	9.9428302
	D to B	7339m.64	9.8656747		F to E	6143m.05	3.7884477
	D to A	7194m.90	3.9570247		F to D	5952m.54	3.7747025
	D to B		3.8656747				
C	Coffee's Point	62° 21′ 23″.7	0.0526387				
D	South Base	48° 29′ 05″.4	9.8743544				
B	Ragged Island	69° 09′ 30″.9	9.9706112				
	C to B	6203m.94	3.7926678				
	C to D	7743m.27	3.8889246				

		° ′ ″		
Z	O to B	00 00 00.0		
∠	B & A	51 30 37.9		
Z	O to A	51 30 37.9	sin	9.8936078
			D	3.6963942
			cos	9.7940492
	y	*x*		3.5900020
	+3890.47	3093.45		3.4904434
	A			

		° ′ ″		
Z	B to O	180 00 00.0		
∠	O & A	63 01 26.8		
∠	A & D	98 10 45.9		
∠	D & C	69 09 30.9		
		50 21 43.6		
Z	B to C	309 38 16.4	sin	9.8865424
			D	3.7926678
			cos	9.8047694
	y	*x*		
	0000.00	5073.68		3.6792102
	—4777.60	3957.65		3.5974372
	—4777.60	9031.33		
	C			

		° ′ ″		
Z	A to O	231 30 37.9		
∠	O & B	65 27 55.3		
∠	B & D	53 19 39.9		
Z	A to D	350 18 13.1	sin	9.2264111
			D	3.9570247
			cos	9.9937510
	y	*x*		
	+3890.47	3093.45		3.1834358
	—1525.58	8928.44		3.9507757
	+2364.89	12021.89		
	D			

		° ′ ″		
Z	C to B	129 38 16.4+		
∠	B & D	62 21 23.7—		
∠	D & E	44 20 45.7—		
Z	C to E	22 56 07.0	sin	9.5907205
			D	3.6643761
			cos	9.9642340
	y	*x*		
	—4777.60	9031.33		3.2550966
	—1799.27	4252.16		3.6286101
	—2978.33	13283.49		
	E			

		° ′ ″		
Z	D to A	170 18 13.1		
∠	A & B	28 29 34.2		
∠	B & C	48 29 05.4		
∠	C & E	36 00 15.2		
∠	E & F	64 48 09.9		
Z	D to F	348 05 17.8	sin	9.3147189
			D	3.7747025
			cos	9.9905460
	y	*x*		
	+2364.89	12021.89		3.0894214
	—1228.63	5834.36		3.7652485
	+1136.26	17846.25		
	F			

		° ′ ″		
Z	E to C	202 56 07.0 +		
∠	C & D	99 38 59.1 —		
∠	D & F	61 14 30.5 —		
Z	E to F	42 02 37.4	sin	9.8258767
			D	3.7884477
			cos	9.8707748
	y	*x*		
	—2978.33	13283.49		3.6143244
	+4114.57	4562.71		3.6592225
	+1136.24	17846.20		
	F			

&c. &c. &c. &c.

MEASUREMENT OF SUBSIDIARY BASE-LINES.

The annual report for 1854 contains a full description of the compensating base apparatus employed in the measurement of the primary bases on the Atlantic Coast, and the report for 1857 a general description of the sliding-contact apparatus for subsidiary or intermediate bases. These intermediate lines are required either as checks upon the series of small triangles extending along the low coasts south of the Delaware, or for the determination of the distance and direction between two places which cannot be connected by triangulation except at very great expense and probable risk of accuracy. In the latter case, a succession of lines and their deviation in direction are measured, and, if the operation is carefully conducted, and the lines on the beach not less than two miles in length, the results, when compared with distances from the primary bases, will not fail to be satisfactory.

To explain fully the different successive operations connected with the measurement of a subsidiary line, it may be, perhaps, the best plan to present an abstract of the report of the measurements made by the compiler on the Virginia Coast, south of Cape Henry, in 1867.

Base apparatus.—The assistant is referred to the description of the apparatus and the mode of using it as given in the annual report for 1857, with the remark that the defects in the original, as first employed in the third measurement of the English base on Hounslow Heath, in 1784, have been successfully remedied. In addition to those important improvements, the rods employed in 1867 were six metres in length instead of four; the level of the sector was made more delicate, and on each of the forward trestles a roller was placed to facilitate the movement of the bar, forward and back, during its final adjustment.

Length of rods.—A comparison of the two rods with the standard six-metre bar should be made at the office in Washington, both before and after they are used in the field, and, if no accident has occurred to either during the interval, the mean of the two comparisons should be adopted as their respective values.

In deducing the length of rod from comparisons with the standard six-metre bar No. 2, the following data may be employed:

Length of standard bar No. 2 at 32° F........................	$5^{m}.99998233$
One division of the scale of comparator, $\frac{1}{14830}$ of an inch........	$0^{m}.00000174$
Co-efficient of expansion for F. scale............................	$0^{m}.00000641$
Thermometer attached to standard—too high..................	—0°.7
Thermometers attached to rods ±, (in this case correct.)	

Comparisons made at the Coast Survey Office, August 10, 1867.

Standard No. 2.		Rod No. 1.		Standard No. 2.		Rod No. 2.	
Therm.	Divisions.	Therm.	Divisions.	Therm.	Divisions.	Therm.	Divisions.
°		°		°		°	
77.3	+21	76.0	—10	75.3	+ 1	74.0	+7
78.0	+15	76.4	+41	76.0	+ 8	74.5	—3
78.5	+18	77.0	+55	77.0	+13	75.0 } 74°.83	+3 } +1
77.93	+18	76.47	+28.67	76.1	+ 7.33	75.0	+3
— 0.70		77.23	+18.00	— 0.7		74.41	+4.00
77.23		+.76	+10.67	75.4		75.40	+7.33
						+ 0.99	—3.33

Computation—length of rod No. 1.

	m
$+0°76 \times 0.00000641 \times 6^{m}$.........	+0.00002923
$+10^{d}.67 \times 0.00000174$.............	+0.00001857
at 77°.23, No. 1, longer than st'd..	+0.00004780
at 77°.23, standard No. 2.........	6.00172188
at 77°.23, rod No. 1..............	6.00176968
at 75°.00, rod No. 1..............	6.00168391

Computation—length of rod No. 2.

	m
$+0°.99 \times 0.00000641 \times 6^{m}$........	+0.00003808
$—3^{d}.33 \times 0.00000174$.............	—0.00000579
at 75°.4, No. 2, longer than st'd..	+0.00003229
at 75°.4, standard No. 2..........	6.00165149
at 75°.4, rod No. 2...............	6.00168378
at 75°.0, rod No. 2...............	6.00166840

Similar comparisons were made in the month of November following, after the return of the apparatus from the field.

	Rod No. 1.	Rod No. 2.
August 10, 1867, length at 75° F..................	6^m.00168391	6^m.00166840
November 21, 1867, length at 75° F...............	6^m.00168692	6^m.00154393
Mean adopted for the measurement................	6^m.00168541	6^m.00160616

Instruments, &c., and organization of party.—There will be required one 12-inch theodolite, two small transits, a levelling instrument, telescope, 20-metre chain, metre-scale and extension dividers, a coil of iron wire, one-eighth of an inch in diameter and 70 metres in length, and a spring balance.

One assistant, to make the contact, give the signals, &c.

One aid, to align the bars, using a transit.

One aid, to record the inclination, temperature, and number of the bar, and, when the measurement halts or stops for the day, to transfer the end of rod to copper tack in stub, employing, for this purpose, the other transit.

Two men, to carry the bar.

Two men, to pick up the trestles, carry them forward, adjust them in line, and level them.

One man, to attend the aid in charge of alignment, bring up instrument, &c.

One man, to keep up the transfer transit, and to be provided with stub, axe, and copper tack for an emergency, and to assist generally.

Cart, horse, and driver, for the transportation of heavy wooden box, in which the bars are kept when not in use; of water, stubs, spades, and tools, and of tent, in case of sudden storm.

The record book.—The record book is ruled and kept as in the following specimen pages, except that the remarks are applicable to the day's work, not to the particular number of bars. The left-hand page contains 20 bars or 120 metres, and, as the stubs of the preliminary measurement are driven at every 120 metres, the last number on each page should be an even number, and should coincide with a stub, in order that an error, in counting or numbering the bars, cannot be carried beyond the page. The thermometers, one for each rod, are read, and the temperature recorded for every ten bars, and oftener, if any unusual delay occurs, and always when the measurement stops, from any cause, whatever may be the number of the last bar. The inclinations are recorded for each rod, and the columns for the mean temperature and corrections for inclination are filled up, as the opportunity may offer.

Measurement of the coast. September 22, 1867. VIRGINIA—SECTION IV. — Station B to station C. Clear. Wind, L, westerly.

Time.	Whole number.	No. of Bar.	Temp.	Inclination. +	Inclination. —	Mean temperatures.	Correction for inclination.	Remarks.
h m			°	′	′	°		
11 25	161	1	77.5	42			.00044790	Stopped for aligning transit to advance.
	162	2	77.5		17		007388	
	163	1			20		010157	
	164	2		7		76.875 × 10	001244	
	165	1		1.23		7[illegible]8.75	174921	
	166	2		21			011198	
	167	1			48		058502	
	168	2			3		000228	
	169	1	76.5		5		000635	
11 41	170	2	76.0		19		009166	Stopped. Stub, copper tack, and cross-lines.
12 43	171	1	74.5	13			004291	
	172	2	74.5	9			002056	
	173	1			20		010157	
	174	2		19		74.25 × 10	009166	
	175	1		56		742.50	079627	
	176	2			37		034761	
	177	1			19		009166	
	178	2			57		082497	
	179	1	74.0	26			017165	
12 56	180	2	74.0		14		004977	Stopped for the day. Stub, copper tack, and cross-lines.
							.00572042	

Preparation of the line.—The locality of the proposed base having been selected, either on the beach, adjoining sand plain, or hard land in the interior, the line is traced, and its direction adjusted to the least uneven ground and to avoid the tide, dunes, or hillocks, and then cleared of all minor obstructions.

Monuments.—After the line has been finally laid out, the monuments are erected. These may be merely the underground permanent marks, brought up level with the surface of the ground, and the terminus of the line marked thereon, the cap or upper block being reserved until the horizontal angles have been observed. The operation of ending the measurement at a given point is less liable to error, and more economical of labor than the process of putting in a temporary mark, and then superseding it by a final one at some time after the measurement has been completed.

Alignment.—The base is aligned by setting up straight poles, prepared for the purpose, at about every half mile. This may be done by adjusting the transit over the mark at one end, fixing the cross-hairs on the signal at the other terminus, and by a system of signals to the aid, who is provided with a telescope, putting the poles in line, working in the direction of the instrument.

During the measurement an aid, with his transit, is stationed in the rear, never more than about one-fourth of a mile from the apparatus, and directs the alignment of the bars by movements of his arm. A small wand, about the size of a lead-pencil, and painted black, is firmly fixed, in a vertical position, at the forward end of each bar, directly over the rod, and when the bar has been approximately brought into position by the men who have it in charge, a signal is made, and the aid perfects the alignment.

Adjustment of the apparatus.—Before commencing the measurement, each bar is appropriately arranged upon trestles, and the knife-edge at one end and the centre of the plane at the other are brought to the same level, by means of a levelling instrument placed about 20 metres from each end. The rod being level, the level and zero of the sector are adjusted to this condition of the rod. The same operation is gone through with after the measurement is completed, to ascertain if the relation between the sector and the rod has changed, or, in other words, if the readings of the sector have truly expressed the inclination of the rod; and, if not, the error. Half of this index-error is the correction to be applied to the recorded inclinations, though, if it is small, as in the following case, and the angles of elevation and depression are about equal in number and value, the error is not appreciable:

	Rod 1, index-error.	Rod 2, index-error.
Before measuring—station A, adjustment...........	0′.0	0′.0
After measurement—station B, compared...........	+1′.0	0′.0

Hence, for every + inclination recorded for rod No. 1, a correction of 0′.5 should be subtracted, and the same added to each — inclination. The sector of rod No. 2 had remained unchanged.

Preliminary measurement.—The preliminary measurement is made with an iron wire, about one-eighth of an inch in diameter, and 60 metres in length. This distance (10 bars) is measured off with the base apparatus, starting from the initial point, should the ground be favorable, and extending in the direction of the base-line. The terminus is marked by cross-lines drawn on the head of a copper tack driven in a stub sunk level with the surface of the ground. The inclinations and temperatures are recorded, in order that the exact distance may be computed. The wire, which has been previously uncoiled, straightened, and otherwise prepared, and also provided with a loop at each extremity, is then stretched between the two marks by a chain staff at the after end, and a weight of forty pounds applied to the other by means of a spring balance. In this condition, and after repeated trials, the measured distance is transferred to and marked on the wire by a fine line cut near each loop.

The wire is then drawn forward, stretched in line, the uniform weight of forty pounds applied, and at a given signal from the aid in charge of the after end, indicating the adjustment of the wire mark to the stub mark, the forward mark is transferred, by a pencil, to the planed surface of a small wooden bench, sunk nearly level with the ground. The pencilled line is then numbered, the wire carried forward, aligned and stretched as before, the after mark adjusted to line on bench, the forward mark transferred to another and similar bench, and so on to the terminus.

The bench, which is about one foot square, and provided with four short legs, is firmly planted in the ground by the pressure of the foot after the wire has been approximately adjusted for di-

rection and distance. Four or five of these benches will be required, one being always left a wire behind as a precaution against accident. Stubs are driven at every second wire or 120 metres apart, to serve as tests of correctness in counting the bars during the final measurement. Each page of the record will commence and end at one of these stubs.

The end of the last wire, before reaching the terminus, should be marked by cross-lines on the usual copper tack and stub, so that when the final measurement reaches the mark, a close comparison may be instituted, if desired, between the two measurements. As the last wire will either fall short of or go beyond the monument, the difference should be measured with the 20-metre chain, a tape line, or metre scale, according to the distance, and duly recorded with its appropriate sign.

The above operation requires very little more time than the ordinary chain measurement, and is much more satisfactory. In order to show the accuracy with which such rapid measurements may be made on level ground, the two following comparisons are presented:

	m
Wire measurement.—A to B $=82$ wires $\times 6^m.00164579 \times 10$	4921.3495
Base apparatus.—A to B $=802$ bars $\times 6^m.00164579$ — excess $=0^m.019+$ Rudie Creek $=107^m.8408+$ temp $=0.^m2107$ — inclination $=0^m.1681$	4921.1843
Wire.—B to C $=71$ wires $\times 6^m.00164579 \times 10$	4261.1685
Apparatus.—B to C $=710$ bars $\times 6^m.00164579+$ deficiency $=0.1016+$ temp $=0^m.2200$ — inclination $=0^m.1676$	4261.3225

The temperature of rods.—The thermometers attached to the apparatus are compared with the standard at the office, and the correction to be applied, if any, is marked on the scale. The temperature, as a rule, is read at every ten bars, and without withdrawing the thermometer from its position next to the rod. Every possible care should be taken to preserve an even or slowly changing temperature, and that the thermometer should express the temperature of the rod. The box in which the bars are deposited at the close of the day's work should be left in an east and west direction, so that one rod or one thermometer may not be found the next morning unduly heated by having been exposed to the morning sun; and should any great difference be noted between the two thermometers, a delay of half an hour is advisable to permit them to settle down to about the same degree. The measurement should stop when the temperature is over 100°.

Inclination of the rods.—The bars should not be allowed, for obvious reasons, to rest for any length of time on the trestles, and as rapidity in the measurement is in some degree essential to its success, no time should be lost, during the operation, in an attempt to keep the bars exactly level. The inclination should be observed while the assistant is perfecting the contact, and the correction therefor will answer every purpose. When the inclination exceeds 3° or 4°, or is beyond the range of the sector, a vertical offset becomes necessary. The transit is set up directly opposite to the end last adjusted, and very carefully levelled. The after bar is then carried forward, placed on its trestles, levelled, and aligned, and then moved backward or forward, as the case may require, approximately by hand, and finally by the slow-motion screw, until the knife edge, adjusted for coincidence of line, is brought in the vertical of the plane of the fixed rod, under the direction of the aid in charge of the transit. When the contour of the ground shows that a vertical offset is unavoidable, the last bar should be made as level as possible. Care should be taken, however, when approaching an elevation or depression in the ground, so to manage the inclination of the bars as to avoid or to have as few as possible of such offsets. A table containing the correction for each minute of inclination may be computed by the following formula:

$R =$ length of rod .... say $6^m.00164579$

$\theta =$ inclination in minutes .... say $25'$

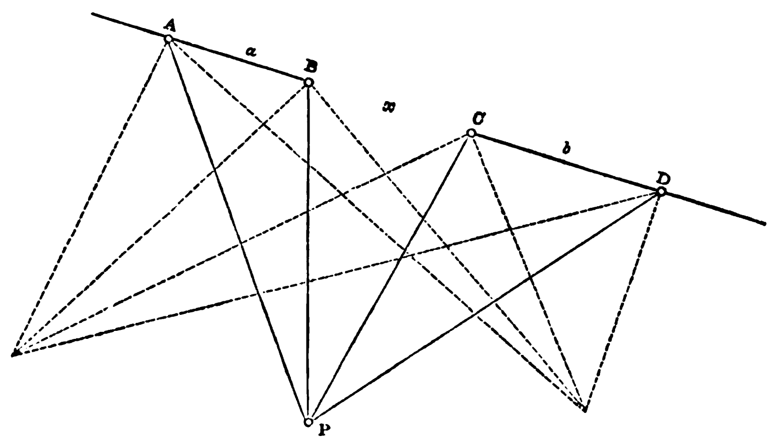
$$\text{correction} = \frac{\sin^2 1'}{2}\theta^2 R \qquad \text{constant} = \frac{\sin^2 1'}{2} = \log 2.626422$$

constant	2.626422
log θ^2	2.795880
log R	0.778270
	6.200572 $= 0^m.00015870$

The distance across a creek, quicksand, &c.—When it is not possible to obtain the desired length of base-line without crossing a short distance in which the bars cannot be used, or it would be unsafe to depend upon them, as in the case of water, quicksand, boggy soil, or even a rapid suc-

cession of great irregularities in the ground, the unmeasured distance should be determined by the following method:

Let AB represent a section of the regularly measured base, about equal to the distance to be crossed, with its ends carefully marked. Recommence the measurement on the other side of creek or bog, and mark off a similar distance CD, all in the line of the base. Set up and adjust the theodolite on firm ground at P and in sight of the stubs at A, B, C, and D. At the intersection of the cross-lines on the tacks at these four points, or in line to P, insert a short wire, or nail, or the smallest object distinctly visible from P. Then measure the angles APD, APC, and APB, and for verification, the angle BPD.



Example.—Crossing of Rudie Creek.

Let AB $= a = 90^{m}.0242 =$ distance corrected for inclination and temperature.
CD $= b = 120^{m}.0316 =$ distance corrected for inclination and temperature.
BC $= x =$ the unmeasured distance.
APB $= A^1 = 19°\ 41'\ 44''.56 =$ mean of observations.
APC $= A^2 = 49°\ 02'\ 29''.77 =$ mean of observations.
APD $= A^3 = 75°\ 22'\ 02''.56 =$ mean of observations.
BPD $= A^4 = 55°\ 40'\ 14''.50 =$ mean of observations.

$$x = -\frac{a+b}{2} \pm \frac{a-b}{2\cos y} \qquad \tan^2 y = \frac{4\,ab}{(a-b)^2} \cdot \frac{\sin A^2 \sin (A^3 - A^1)}{\sin A^1 \sin (A^3 - A^2)}$$

$\sin (A^3 - A^1) = 55°\ 40'\ 16''.25$	9.9168826	
$\sin A^2 = 49°\ 02'\ 29''.8$	9.8780538	
co. $\sin (A^3 - A^2) = 26°\ 19'\ 32''.8$	0.3531314	
co. $\sin A^1 = 19°\ 41'\ 44''.6$	0.4723380	
$\log a = 90^{m}.0242$	1.9543593	
$\log b = 120^{m}.0316$	2.0792956	
log 4	0.6020600	
co. $\log (a-b)^2$	7.0455432	
$\tan^2 y$	2.3016639	
$\tan y$	1.1508319	
y	$85°\ 57'\ 29''.7$	
$\log (a-b)$	1.4772284	
co. $\log \cos y$	1.1519135	
co. log 2	9.6989700	
$\frac{a-b}{2\cos y}$	2.3281119	$212^{m}.8687$
		$\frac{a+b}{2} = 105^{m}.0279$
		$x = 107^{m}.8408$

For verification, change the position of P, and from the new point observe the same angles, and with these recompute x. In the above, the unmeasured distance determined from two positions was found to be identical.

Verification of measurement.—Care must be taken, while making the contact, to bring the knife-edge to the centre of plane; to hold the magnifying glass parallel with the rod when bringing the line on the index plate and slide to coincide; to make no mistake in reading the thermometer or angle of inclination, and especially in the adjustment of the transit for vertical offsets, or when the end of the rod is to be transferred to a stub.

To test the accuracy of the measurement, a part of the line should be always remeasured, and, if there is any doubt, the entire line. The following comparison is copied from the record of the measurement on the Virginia Coast:

August 30, 1867, from bar 148 to bar 286, inclusive,	m	
Mean of rods=$6^m.00164579 \times 138$ bars.............	828.22711902	
Correction for temperature above 75°.............	+0.00227743	
Correction for inclination of rods.................	—0.02329017	m
		828.20610628
September 2, same distance remeasured,		
Mean of rods=$6^m.00164579 \times 138$ bars.............	828.22711902	
Correction for temperature 75°....................	+0.02084498	
Correction for inclination of rods.................	—0.02279271	
Correction for error in alignment of 19 bars.......	+0.00007717	
Measured excess, at 286th bar.....................	—0.01970000	
		828.20554846
Difference about two-hundredths of an inch		0.00055600

Length of line.—The mean temperature of the rods during the measurement is obtained by multiplying the number of bars (usually, but not always, ten) between the observed temperatures, by the mean of the four temperatures, and by dividing the sum of these quantities by the total number of bars measured. The corrections for inclination are added, and the sum subtracted from the measured distance.

	m
Rod No. 1=$6^m.00168541$ at 75° F.$\times$404 bars..................	2424.68090564
Rod No. 2=$6^m.00160616$ at 75° F.$\times$404 bars..................	2424.64888864
Distance across Rudie Creek computed.......................	+107.84080000
Distance beyond 826th bar to centre of station..................	+ 0.71930000
Mean temperature=81°.77, correction for 6°.77 above 75°.......	+ 0.21094919
Correction for inclination of rods..............................	— 0.16968103
	4957.93116244

When two lines and the included angle are measured:

Let $a = 4957^m.931162$

$b = 4307^m.587099$

$C = 177° \ 37' \ 59''.82$, or deviation from straight line $= 2° \ 22' \ 00''.18$

$\theta = 2° \ 22' \ 01''.69$, reduced to angle of chords, or $142'.0282$

$$\text{correction} = \frac{\sin^2 1'}{2} \cdot \frac{a\,b\,\theta^2}{a+b}$$

log θ..	2.1523746	
log θ..	2.1523746	
log a..	3.6953005	
log b..	3.6342341	
co. log $(a+b)$..................................	6.0331303	
log constant $\frac{\sin^2 1'}{2}$...........................	2.6264222	
		m
	0.2938363	—1.967247
		$a+b$=9265.518261
Length of line connecting extreme points.......................		9263.551014

Four lines were measured in the fall of 1867, the maximum deviation in direction being 4° 27′ 06″. The correction to the sum of the measured distances to reduce them to a straight line was $32^m.616$,

And the resulting length of the direct line	m 14270.931
Reduction to mean level of sea	—0.005
	14270.926

To reduce to level of half-tide,

K = the distance or length of line.
h = mean height of bars above half-tide.
R = radius of curvature of the arc.

$$\text{Correction} = \frac{K\,h}{R}$$

log K = $14270^m.926$	4.15445
log h = $2^m.36$	0.37291
co. log R	3.19660
correction = $0^m.005296$	7.72400

At each station the horizon was closed by observing the supplemental angle, and while occupying the initial point, the azimuth of the triangulation was transferred to the terminus of each of the measured lines, as well as to the most distant visible station, to serve as checks and conditions.

To convert metres at 32° F. into the United States standard measures of length for inches, feet, and yards, at 62° F.

Metres × 39.36850535 = inches, or log metres	+1.5951489
Metres × 3.28070878 = feet, or log metres	+0.5159677
Metres × 1.09356959 = yards, or log metres	+0.0388464
Metres ÷ 1609.40831 = miles, or log metres	—3.2066665

RECORDS, DUPLICATES, AND COMPUTATIONS.

Beside the monthly and annual reports to be made to the Superintendent, in conformity with his "General Instructions," the following records, appertaining to the triangulation, are directed to be forwarded to or deposited at the office:

I. A carefully compared copy of the original observations.
II. A copy of the descriptions of stations.
III. A copy of the plan of the triangulation on a scale of $\frac{1}{10000}$. This plan should show each unobserved angle by the usual broken line for half the length of one or both of the enclosing sides, and should contain a sketch of the shore-line and of the general features of the country embraced within its limits.

The above duplicates are generally kept up in the field as the work advances, and are forwarded to the office at the close of the season's operations.

IV. The original volumes containing the observations of horizontal and vertical angles.
V. The original volume, entitled "Descriptions of Stations."
VI. An abstract of the measurements and resulting angles, corrected, if necessary, for phase of signals and eccentricity of stations.
VII. A cahier containing the triangle side computations.
VIII. The L. M. Z. computations.

These are all forwarded to the office as soon as possible after the assistant has completed his computations.

APPENDIX No. 8.

METHOD OF ADJUSTMENT OF THE SECONDARY TRIANGULATION OF LONG ISLAND SOUND.

COMMUNICATED BY CHARLES A. SCHOTT, ASSISTANT COAST SURVEY.

MAY, 1868.

The secondary triangulation of Long Island Sound, executed by the late Assistant Edmund Blunt, between 1836 and 1843, offers a peculiarity in its conditions of adjustment, for which reason it has been thought desirable to present a brief account of the same in connection with the final results reached. The peculiarity in question consists in the necessity of an exact conformity to the primary triangulation, to which this secondary series is joined at each end. Referring to the accompanying sketch, (No. 6,) it will be seen that we have here a complete circuit of triangulation 315 miles in length, 220 of which are formed by primary triangles already adjusted and unchangeable, and 95 measured by the intervening secondary triangles comprised between the primary line Tashua–Ruland in the west, and the sub-primary line McSparran–East Rock, in the east. The problem to be solved is to adjust, by application of the method of least squares, the small geometrical contradictions in the secondary triangulation, and at the same time to superpose perfectly the terminal side upon its corresponding primary, irrespective of the end from which we proceed to calculate, and of the particular ellipsoid of revolution that may be employed for the development of the whole triangulation. The problem has been solved analytically, but the solution cannot be practically applied in all its rigor on account of excessive complexity; and, although some methods have lately been pointed out* by which a solution is supposed practicable, the treatment here employed has the merit of being applicable in all similar cases, with the preservation of so much strictness as will render its results nearly as probable as those obtained by a mathematically rigorous treatment. At any rate, the results deduced cannot differ from the *most* probable ones by an amount exceeding their probable error. The successive steps of the process of reduction are as follows:

1. The angles measured *at each station* are adjusted whenever they present combinations. A special selection of the objects sighted on is made, with the view of admitting only such directions or angles as have the requisite degree of accuracy. Weights are introduced in accordance with the number of repetitions measured. At each of the four primary stations the primary directions must remain unchanged and the secondary directions must be made to conform to them.

2. The geometrical conditions of the secondary triangulation are found, and the normal equations are established and solved, with consideration of weights. The triangle-sides are then computed, starting from one of the terminal primary lines, from which the latitude, longitude, and azimuth computation of the whole of the secondary triangulation is carried out.

3. Unless there be an accidental agreement, we shall then find a discrepancy in the latitude and longitude of the two points of the terminal line, opposite the one started from, when we compare the same with the corresponding latitude and longitude already known through the primary work. The discrepancy in question manifests itself in three ways: first, by a difference in length between the side as resulting from the secondary and as given in the primary triangulation; second, by a difference in azimuth; and, third, by a want of coincidence of the lines. To adjust the first difference, an equation of length, which is in the nature of a side-equation, is carried through the entire secondary triangulation; to adjust the second, an azimuth equation is introduced, which

* See Astronomische Nachrichten, Nos. 1690 and 1697; also, P. A. Hansen's Treatise on the Method of Least Squares in General, and its Application to Geodesy, Leipsic, 1867.

is in the nature of an angle-equation, at the same time keeping *all other conditional equations satisfied.* In this case we have, therefore, two equations in addition to the former number of normal equations.

4. A repetition of the computation of the triangles thus adjusted, and of the latitude, longitude, and azimuth computation will bring out a small residual difference in lat. ($d\varphi$) and long. ($\delta\lambda$) of the end point (and the same for the opposite end) of the secondary line when compared with the corresponding primary line; we may therefore compute the small diagonal in distance and azimuth. If we now conceive a line drawn from each point of the secondary triangulation in the direction of the above azimuth, and varying in length proportional to the distance from the primary starting-line, as measured along the sides of the triangles, we produce a series of eccentric stations, the eccentricity being zero at the end started from and gradually increasing to a maximum, or to the value $\sqrt{d\varphi^2+d\lambda^2}$ (where the quantities $d\varphi$ and $d\lambda$ are expressed in meters) at the opposite end of the triangulation.

5. We next reduce each station to center and compute the triangle sides anew, and finally carry a latitude, longitude, and azimuth computation over the secondary work for the third time, when no contradiction whatever will appear in the results. It will be seen that in this process of reduction the results do not depend upon the particular ellipsoid of rotation employed, (provided the same is used for the 1ry and 2ry $\Delta' n$,) and that the triangle and other geometrical checks will remain satisfied, if hereafter we choose to develop the whole triangulation upon any other osculating geometrical surface.

The practical application of the above process to the Long Island Sound secondary triangulation will be given briefly, referring the reader for the general method to Appendix No. 14, Coast Survey Report of 1864.

We have here in all thirty-two conditional equations among the angles themselves, as measured at the several stations, making the average correction to any one angle from this cause $=\pm 1''.33$.

The angles were measured with a twelve-inch repeating theodolite by Simms. As a specimen of these adjustments at any one station the following short reduction* of the angular measures at Shelter Island is inserted:

SHELTER ISLAND.

Name of stations.	Observed angle.	Weight.	Corrections.	Seconds corrected.
	° ′ ″		″	″
Williams–Nickerson	27 42 44.55	12	$v_1 = -1.59$	42.96
Williams–Gull Island Light	79 16 01.78	12	$v_2 = +1.54$	03.32
Williams–Montauk	115 08 12.47	4	$v_3 = -2.31$	10.16
Nickerson–Mount Prospect	51 28 22.94	12	$v_4 = -1.54$	21.40
Mount Prospect–Gull Island Light	0 04 60.50	12	$v_5 = -1.54$	58.96
Gardiner's Island–Shinnecock	120 24 57.30	15	$v_6 = +1.50$	58.80
Shinnecock–Nickerson	161 15 35.58	6	$v_7 = +3.94$	39.52
Nickerson–Gardiner's Island	78 19 19.79	12	$v_8 = +1.89$	21.68
Montauk–Shinnecock	111 18 53.78	18	$v_9 = -0.50$	53.28
Nickerson–Montauk	87 25 27.15	6	$v_{10} = +0.05$	27.20
Friarshead–Williams	87 35 41.19	6	$v_{11} = -1.65$	39.54
Shinnecock–Friarshead	45 57 17.30	36	$v_{12} = -0.28$	17.02

From the combinations we derive the conditional equations,

$$
\begin{array}{rl}
1. & 0=+6''.21+v_1-v_2+v_4+v_5 \\
2. & 0=-7''.33+v_6+v_7+v_8 \\
3. & 0=-2''.72-v_1+v_3+v_7+v_9 \\
4. & 0=-0''.77+v_1-v_3+v_{10} \\
5. & 0=+7''.46+v_1-v_7+v_{11}+v_{12}
\end{array}
$$

* See p. 81, Report of 1854.

and the equations of correlatives,

$\frac{180}{P}$	v	C_1	C_2	C_3	C_4	C_5
15	1	+1		−1	+1	+1
15	2	−1				
45	3			+1	−1	
15	4	+1				
15	5	+1				
12	6		+1			
30	7		+1	+1		−1
15	8		+1			
10	9			+1		
30	10				+1	
30	11					+1
5	12					+1

using, for convenience, $\frac{180}{P}$ for $\frac{1}{P}$ as multiplier.

From the above we form the normal equations,

	C_1	C_2	C_3	C_4	C_5
$0=+6.21$	+60		−15	+15	+15
$0=-7.33$		+57	+30		−30
$0=-2.72$	−15	+30	+100	−60	−45
$0=-0.77$	+15		−60	+90	+15
$0=+7.46$	+15	−30	−45	+15	+80

hence,

$$\begin{cases} C_1=-0.1025 \\ C_2=+0.1258 \\ C_3=-0.0497 \\ C_4=+0.0017 \\ C_5=-0.0551 \end{cases}$$

which produce the corrections v_1 to v_{12}, as given above.

There are seventeen angle and seven side equations in the figure of the secondary triangulation. Their treatment by the method of least squares and the triangle side, and latitude, longitude, and azimuth computations, starting from Ruland–Tashua, gave the following result for the terminal line, McSparran–East Rock:

Log. distance - - - - - - - - - - -	4.3526260
True log. distance - - - - - - - -	4.3526300
Azimuth of line, McSparran–East Rock - -	282° 45′ 31″.382
True azimuth of line, McSparran–East Rock -	28″.446

Difference at McSparran −2″.936, and at East Rock −2″.927; mean −2″.931.

We consequently add the following equation (XXVI) to produce an agreement in *length*:

$$\frac{14..15}{2..1}=\frac{\sin 1.2.3 \sin 4.1.3 \sin 4.3.5 \sin 6.4.5 \sin 7.6.5 \sin 7.5.8}{\sin 2.3.1 \sin 3.4.1 \sin 3.5.4 \sin 5.6.4 \sin 5.7.6 \sin 5.8.7}$$

$$\times\frac{\sin 10.7.8 \sin 10.8.11 \sin 13.10.11 \sin 14.13.11 \sin 14.11.15}{\sin 8.10.7 \sin 8.11.10 \sin 11.13.10 \sin 11.14.13 \sin 11.15.14}$$

The numbers refer to the respective stations, as given in the sketch. The directions $\frac{1}{2}$, $\frac{2}{1}$, $\frac{14}{15}$, and $\frac{15}{14}$ are considered fixed. The equation is to be established with plane angles.

EQUATION XXVI.

$$
\begin{aligned}
0=-0.40&+.03\binom{3}{2}-.16\binom{4}{1}+.16\binom{3}{1}-.08\binom{4}{3}+.08\binom{5}{3}-.26\binom{6}{4}\\
&+.26\binom{5}{4}-.02\binom{7}{6}-.10\binom{5}{6}-.01\binom{7}{5}+.01\binom{8}{5}-.13\binom{10}{7}\\
&+.13\binom{8}{7}-.08\binom{10}{8}+.08\binom{11}{8}-.12\binom{13}{10}+.12\binom{11}{10}-.08\binom{14}{13}\\
&+.04\binom{11}{13}-.37\binom{14}{11}+.37\binom{15}{11}+.10\binom{2}{3}-.10\binom{1}{3}+.06\binom{3}{4}\\
&-.06\binom{1}{4}+.09\binom{3}{5}-.09\binom{4}{5}+.12\binom{4}{6}+.08\binom{5}{7}-.08\binom{6}{7}\\
&+.22\binom{5}{8}-.22\binom{7}{8}+.02\binom{8}{10}-.02\binom{7}{10}+.07\binom{8}{11}-.07\binom{10}{11}\\
&+.04\binom{10}{13}+.07\binom{11}{14}-.07\binom{13}{14}+.15\binom{11}{15}
\end{aligned}
$$

The equation (XXV) to produce an agreement in azimuth is as follows:

$$0=+2''.93+\binom{3}{2}-\binom{2}{3}+\binom{5}{3}-\binom{3}{5}+\binom{8}{5}-\binom{5}{8}+\binom{11}{8}-\binom{8}{11}+\binom{15}{11}-\binom{11}{15}$$

We now reëstablish the equations of correlatives and the normal equations, solve them, compute the triangle sides, and latitudes, longitudes, and azimuths of all the points, and find, as it should be, the line, McSparran–East Rock, to agree in *length and direction* but not yet to coincide with the primary line; we have at McSparran $d\varphi=-0''.007$, (about 8 inches,) $d\lambda=-0''.038$, (less than 3 feet;) the primary line lying apparently to the south and east not quite 3 feet off, which, in a total distance of 95 statute miles, is its $\frac{1}{169000}$ part nearly; but the whole of this error is not to be attributed to the secondary work, a part of it belonging to the 220 miles of primary work.

The latitude and longitude of each point is now corrected proportionally to the distance from Tashua, where $d\varphi$ and $d\lambda=0$, with the maximum correction at McSparran, as stated above. The *relative* change of any two adjacent stations is, in maximo, about 7 inches. These corrections are as follows:

	In lat.	In long.
	"	"
Friarshead	—0.001	—0.005
Sugarloaf	2	8
Williams	2	12
Shelter Island	2	10
Nickerson	3	15
Mount Prospect	4	19
Montauk	4	20
Lanternhill	5	25
Watchhill	5	26
Chaplin	6	32
Block Island	5	29
Broadhill	7	35
McSparran	7	38
East Rock	—0.007	—0.038

Having thus found the correct latitude and longitude of each point, we reconstruct the triangles, correcting each angle for the above eccentricity for the part due to its own change of apex as well as for that due to the shifting of the directions to the changed stations. The sum of the eccentricity corrections in each triangle is zero.

The following arrangement for the computation of the eccentricity will be found convenient:

Reduction of Friarshead to final position [$d = 0^m.120$].

Station.	Azimuth. ° ′	Direction. δ ° ′	$\frac{d \sin \delta}{D}$	$\times \frac{1}{\sin 1''}$	Eccentricity. ″
			9. 0792	5. 3144	
Centre	284 52	0 00			
Ruland	61 29	136 37	9. 8369 8. 9161 4. 4661	4. 4500 9. 7644	+0. 581
Tashua	126 24	201 32	9. 5647 8. 6439 4. 7354	3. 9085 9. 2229	−0. 167
Sugarloaf	179 36	254 44	9. 9844 9. 0636 4. 6524	4. 4119 9. 7256	−0. 532
Williams	202 16	277 24	9. 9964 9. 0756 4. 6639	4. 4117 9. 7261	−0. 532
Shelter Island	248 56	324 04	9. 7685 8. 8477 4. 5193	4. 3284 9. 6428	−0. 439

Similarly we find for reduction of Sugarloaf [$d=0^m.196$],

	Eccentricity.
Williams	$+0''.027$
Shelter Island	$+0''.575$
Friarshead	$+0''.894$
Tashua	$+0''.344$

and so on for the remainder of the stations.

The eccentricity corrections for the first and second triangles consequently become:

1st △		2d △	
Friarshead	$-0''.748$	Sugarloaf	$-0''.018$
Ruland	$+0''.581$	Friarshead	$+0''.529$
Tashua	$+0''.167$	Tashua	$-0''.511$
&c.		&c.	

The results of the final triangle-sides computation, which proves the correctness of the whole, are as follows:

Resulting angles and distances of the secondary triangulation of Long Island Sound, between the lines Tashua–Ruland and McSparran–East Rock.

No. of triangle.	Name of stations.	Observed angles. °	′	″	Corrections by adjustment. ″	Seconds of resulting angles. ″	Spherical excess. ″	Log. distances of opposite sides.	Distances, in meters.	Distances, in statute miles.
	Friarshead	64	55	40. 647	— . 332	40. 315	1. 219	4. 6958477	49641. 82	30. 84
1	Ruland	82	49	18. 258	+ . 993	19. 251	1. 219	4. 7354112	54376. 49	33. 79
	Tashua	32	15	03. 845	+ . 245	04. 090	1. 218	4. 4660658	29245. 95	18. 17
	Sugarloaf	74	10	49. 040	+ 1. 522	50. 562	1. 655	4. 7354112	54376. 49	33. 79
2	Friarshead	53	11	24. 830	+ 1. 592	26. 422	1. 654	4. 6556115	45249. 26	28. 12
	Tashua	52	37	47. 360	+ . 619	47. 979	1. 654	4. 6523985	44915. 73	27. 91
	Shelter Island	67	43	46. 190	— 2. 859	43. 331	1. 175	4. 6523985	44915. 73	27. 91
3	Friarshead	69	20	18. 050	— 2. 018	16. 032	1. 175	4. 6571952	45414. 57	28. 22
	Sugarloaf	42	56	04. 820	— . 657	04. 163	1. 176	4. 5193178	33061. 14	20. 54
	Williams	74	52	23. 710	+ 1. 236	24. 946	. 675	4. 6523985	44915. 73	27. 91
4	Friarshead	22	40	04. 360	— 1. 104	03. 256	. 675	4. 2536031	17930. 94	11. 14
	Sugarloaf	82	27	33. 460	+ . 364	33. 824	. 676	4. 6639407	46125. 46	28. 66
	Williams	120	36	34. 980	+ 1. 131	36. 111	. 438	4. 6571952	45414. 57	28. 22
5	Shelter Island	19	51	53. 350	+ 2. 192	55. 542	. 439	4. 2536029	17930. 93	11. 14
	Sugarloaf	39	31	28. 640	+ 1. 022	29. 662	. 438	4. 5261049	33581. 87	20. 87
	Williams	45	44	11. 270	— . 106	11. 164	. 938	4. 5193178	33061. 14	20. 54
6	Shelter Island	87	35	39. 540	— . 666	38. 874	. 939	4. 6639407	46125. 46	28. 66
	Friarshead	46	40	13. 690	— . 913	12. 777	. 938	4. 5261049	33581. 87	20. 87
	Nickerson	68	57	47. 510	+ . 243	47. 753	. 472	4. 5261049	33581. 87	20. 87
7	Shelter Island	27	42	42. 960	— . 381	42. 579	. 472	4. 2235348	16731. 50	10. 40
	Williams	83	19	31. 060	+ . 024	31. 084	. 472	4. 5531068	35736. 07	22. 20
	Montauk	44	10	45. 400	— . 152	45. 248	1. 158	4. 5531068	35736. 07	22. 20
8	Shelter Island	87	25	27. 200	— . 535	26. 665	1. 158	4. 7094965	51226. 72	31. 83
	Nickerson	48	23	50. 740	+ . 821	51. 561	1. 158	4. 5837020	38344. 41	23. 83
	Mount Prospect	64	38	28. 870	— 2. 206	26. 664	. 839	4. 5531068	35736. 07	22. 20
9	Shelter Island	51	28	21. 400	+ . 437	21. 837	. 840	4. 4904907	30937. 89	19. 22
	Nickerson	63	53	13. 570	+ . 448	14. 018	. 840	4. 5503536	35510. 24	22. 06
	Mount Prospect	143	24			38. 963	. 358	4. 7094965	51226. 72	31. 83
10	Montauk	21	05	60. 030	— . 378	59. 652	. 358	4. 4904907	30937. 89	19. 22
	Nickerson	15	29	22. 830	— . 371	22. 459	. 358	4. 3608069	22951. 28	14. 26
	Mount Prospect	78	46			12. 300	. 677	4. 5837020	38344. 41	23. 83
11	Montauk	65	16	45. 430	— . 530	44. 900	. 676	4. 5503535	35510. 23	22. 06
	Shelter Island	35	57	05. 800	— . 971	04. 829	. 676	4. 3608067	22951. 27	14. 26
	Lanternhill	82	16	14. 970	+ 1. 188	16. 158	1. 209	4. 7094965	51226. 72	31. 83
12	Montauk	39	18	40. 190	— . 804	39. 386	1. 209	4. 5152233	32750. 90	20. 35
	Nickerson	58	25	08. 210	— . 127	08. 083	1. 209	4. 6438471	44039. 90	27. 36
	Lanternhill	64	23	41. 370	— . 488	40. 882	. 584	4. 4904907	30937. 89	19. 22
13	Mount Prospect	72	40	33. 230	+ 2. 017	35. 247	. 584	4. 5152233	32750. 90	20. 35
	Nickerson	42	55	45. 380	+ . 242	45. 622	. 583	4. 3685917	23366. 39	14. 52
	Lanternhill	17	52	33. 600	+ 1. 674	35. 274	. 267	4. 3608068	22951. 28	14. 26
14	Montauk	18	12	40. 160	— . 425	39. 735	. 267	4. 3685919	23366. 40	14. 52
	Mount Prospect	143	54			45. 793	. 268	4. 6438473	44040. 00	27. 36
	Block Island	71	58	55. 380	— 1. 195	54. 185	1. 011	4. 6438472	44039. 99	27. 36
15	Montauk	69	12	04. 690	+ 1. 333	06. 023	1. 011	4. 6364212	43293. 35	26. 90
	Lanternhill	38	49	03. 910	— 1. 085	02. 825	1. 011	4. 4628414	29029. 62	18. 04
	Watchhill	63	55	27. 420	+ 3. 654	31. 074	. 570	4. 4628414	29029. 62	18. 04
16	Block Island	59	51	08. 140	+ . 558	08. 698	. 571	4. 4463406	27947. 35	17. 36
	Montauk	56	13	22. 440	— . 500	21. 940	. 571	4. 4291659	26863. 70	16. 69

Resulting angles and distances of the secondary triangulation of Long Island Sound, &c.—Continued.

No. of triangle.	Name of stations.	Observed angles.	Corrections by adjustment.	Seconds of resulting angles.	Spherical excess.	Log. distances of opposite sides.	Distances, in meters.	Distances, in statute miles.
		° ′ ″	″	″	″			
	Watchhill	146 32 32.580	— .792	31.788	.233	4.6438472	44039.99	27.36
17	Montauk	12 58 42.250	+ 1.831	44.081	.234	4.2538331	17940.44	11.15
	Lanternhill	20 28 43.690	+ 1.142	44.832	.234	4.4463406	27947.35	17.36
	Watchhill	149 31 60.000	— 2.862	57.138	.207	4.6364212	43293.35	26.90
18	Lanternhill	18 20 20.220	— 2.226	17.994	.207	4.4291661	26863.72	16.69
	Block Island	12 07 47.240	— 1.752	45.488	.206	4.2538331	17940.44	11.15
	Champlin	59 40		29.273	.209	4.2538331	17940.44	11.15
19	Watchhill	42 40 45.780	+ 1.247	47.027	.209	4.1489001	14089.65	8.75
	Lanternhill	77 38 46.080	— 1.753	44.327	.209	4.3075599	20302.99	12.62
	Champlin	102 08 26.520	+ .424	26.944	.443	4.6364212	43293.35	26.90
20	Block Island	18 33 08.730	— .677	08.053	.444	4.1489001	14089.65	8.75
	Lanternhill	59 18 25.860	+ .474	26.334	.444	4.5807011	38080.37	23.66
	Champlin	42 27		57.676	.441	4.4291660	26863.71	16.69
21	Block Island	30 40 55.970	— 2.430	53.540	.442	4.3075598	20302.98	12.62
	Watchhill	106 51 14.220	— 4.111	10.109	.442	4.5807010	38080.36	23.66
	McSparran	70 26 25.590	— 2.325	23.265	.805	4.5807010	38080.36	23.66
22	Block Island	41 54 46.210	+ .165	46.375	.804	4.4312914	26995.50	16.77
	Champlin	67 38 51.510	+ 1.263	52.773	.804	4.5725945	37376.15	23.22
	Broadhill	109 38		05.919	.421	4.5807010	38080.36	23.66
23	Block Island	29 49 48.740	+ 2.234	50.974	.421	4.3034576	20112.11	12.50
	Champlin	40 32 04.080	+ .290	04.370	.421	4.4195676	26276.50	16.33
	Broadhill	107 39 31.040	+ 1.264	32.304	.210	4.4312914	26995.50	16.77
24	Champlin	27 06 47.430	+ .976	48.406	.209	4.1109830	12911.69	8.02
	McSparran	45 13 39.620	+ .298	39.918	.209	4.3034577	20112.11	12.50
	Broadhill	142 42		21.770	.174	4.5725945	37376.15	23.22
25	McSparran	25 12 45.970	— 2.620	43.350	.174	4.4195676	26276.50	16.33
	Block Island	12 04 57.470	— 2.068	55.402	.174	4.1109830	12911.69	8.02
	East Rock	21 04 09.162	— .395	08.767	.213	4.1109830	12911.69	8.02
26	Broadhill	38 50		11.743	.213	4.3526303	22523.21	13.99
	McSparran	120 05 39.577	+ .552	40.129	.213	4.4924096	31074.89	19.31
	East Rock	55 23 08.842	+ .516	09.358	.710	4.5725945	37376.15	23.22
27	Block Island	29 43 52.560	+ 3.430	55.990	.710	4.3526300	22523.20	13.99
	McSparran	94 52 53.607	+ 3.174	56.781	.709	4.6556187	45250.01	28.12
	East Rock	34 18 59.680	+ .911	60.591	.671	4.4195676	26276.50	16.33
28	Block Island	41 48 50.030	+ 1.361	51.391	.671	4.4924094	31074.88	19.31
	Broadhill	103 52		10.030	.670	4.6556187	45250.01	28.12

APPENDIX No. 9.

RESULTS OF THE MEASURE OF AN ARC OF THE MERIDIAN OF 3° 23′, BETWEEN NANTUCKET AND FARMINGTON, MAINE.

REPORTED BY CHARLES A. SCHOTT, ASSISTANT COAST SURVEY.

NOVEMBER 30, 1867.

The following results of the measure of an arc of the meridian, extending over 233 miles (375 kilometers) along the coast of Massachusetts, New Hampshire, and Maine, are incidentally due to the general geodetic and astronomical operations of the Coast Survey, and were specially deduced on account of the more general interest attaching to this kind of results, due to the comparative facility of combination with similar results in other parts of the globe. In the ordinary progress of the survey other arc measures may be expected from time to time.

The terminal points of the arc (see accompanying sketch No. 6) are Nantucket Cliff, in the south, (lat. 41° 18′,) and Farmington, Maine, (lat. 44° 40′,) in the north; its total length, therefore, but little exceeds (by 18 miles) that of the arc of Peru, which is 9° further west in longitude. It is composed of six parts, nearly equal in extent. The astronomical latitude was determined at the following stations: Nantucket, Manomet, Thompson, Agamenticus, Independence, Sebattis, and Farmington, all lying within 50 kilometers of the meridian of Nantucket. The astronomical azimuth depends upon ten stations in the immediate vicinity of the arc, which lies in longitude 70⅓° west of Greenwich.

LENGTH OF THE ARC.

1. The geodetic measures having been finally adjusted by application of the method of least squares, the length of the arc and its subdivisions were found by four different methods, the principles of which may be briefly stated as follows:

First method.—By computing spherical rectangular co-ordinates, with respect to a middle meridian, and ascertaining the difference (on that meridian) between the foot of the perpendicular and parallel passing through any latitude station. This method,* known to be not strictly rigorous. proved insufficient in accuracy, and gave the total length of the arc 4^m in excess of the true value,

Second method.—This method consists in *re-developing* the triangulation from the surface of the ellipsoid used in our latitude, (φ) longitude, (λ) and azimuth (α) computations.† For this purpose a new φ, λ, α computation was first made, satisfying, or nearly so, the conditions, Σ of differences of astronomical and geodetic latitudes $=0$, and Σ of differences of astronomical and geodetic azimuths $=0$. It was checked by computing once from the north and once from the south; any of the resulting values were found subject to no greater uncertainty than $\pm 0''.001$. The elliptic arc between any two latitudes is computed by the formula‡

$$S=\frac{g\,l''}{3600}-\frac{180}{\pi}g\left(2\,\alpha\sin l\cos 2\,L-\alpha'\sin 2\,l\cos 4\,L+\frac{2}{3}\alpha''\sin 3\,l\cos 6\,L-\ \&c.\right)$$

where

S=distance of parallels.

a=equatorial semi-diameter $6377397^m.16$ [6.804643464]

b=polar semi-diameter $6356078^m.96$ [6.803189284]

$$n=\frac{a-b}{a+b}$$

$$N=1+\left(\frac{3}{2}\right)^2 n^2+\left(\frac{3\,.\,5}{2\,.\,4}\right)^2 n^4+\ \ldots$$

* For an exposition of the method, see Airy's "Figure of the Earth," p. 199.

† For the formulæ, see Appendix No. 36, Coast Survey Report of 1860.

‡ Bessel, in Astronomische Nachrichten, No. 333.

$$N\alpha=\frac{3}{2}n+\frac{3.5}{2.4}\cdot\frac{3}{2}n^3+\frac{3.5.7}{2.4.6}\cdot\frac{3.5}{2.4}n^5+\ldots$$

$$N\alpha'=\frac{3.5}{2.4}n^2+\frac{3.5.7}{2.4.6}\cdot\frac{3}{2}n^4+\ldots$$

$$N\alpha''=\frac{3.5.7}{2.4.6}n^3+\frac{3.5.7.9}{2.4.6.8}\cdot\frac{3}{2}n^5+\ldots$$

$N\alpha'''=$&c., &c.

$\varphi'=$latitude of higher parallel.

$\varphi=$latitude of lower parallel.

$\varphi'-\varphi=l$

$\varphi'+\varphi=2\,L$

$a(1-n)^2(1+n)\,N=\frac{180}{\pi}g$

The above formula, when expressed, numerically becomes

$S=[1.4894921\ 5]\,l''-[4.5048417]\sin l\cos 2L+[1.52451]\sin 2l\cos 4L-[\bar{8}.639]\sin 3l\cos 6L$

Computing the partial arcs and the whole arc, we find by this formula,

	S
Nantucket–Manomet	70429m.457
Manomet–Thompson	76002m.148
Thompson–Agamenticus	67971m.694
Agamenticus–Independence	59535m.576
Independence–Sebattis	42718m.163
Sebattis–Bannock	65556m.502
Bannock–Farmington	−6989m.296
Sum	375224m.244
Total arc	375224m.27

Third method.—This method consists in computing for each triangle-side (which goes to make up the arc) the differences of parallels by means of its length and forward and reverse azimuths. The latter are known from our φ, λ, α computations, and S becomes known by the formula*

$$S=s\frac{\cos\frac{1}{2}(\alpha+\alpha')}{\cos\frac{1}{2}(\alpha-\alpha')}\left\{1+\frac{1}{12}\left(\frac{s\rho'}{a}\right)^2\frac{\sin\alpha\sin\alpha'}{\cos^2\frac{1}{2}(\alpha-\alpha')}+\frac{1}{240}\left(\frac{s\rho'}{a}\right)^4\frac{\sin\alpha\sin\alpha'}{\cos^2\frac{1}{2}(\alpha-\alpha')}(2-3k^2)+\ldots\right\}$$

where

$$\sin\alpha\sin\alpha'=1-k^2,\qquad \rho'^2=1+e^2\cos(u+u')$$

$$\tan u=\tan\varphi\sqrt{1-e^2},\qquad \tan u'=\tan\varphi'\sqrt{1-e^2}$$

For our application the first two terms suffice, and the formula was used in the form,†

$$S=s\frac{\cos\frac{1}{2}(\alpha+\alpha')}{\cos\frac{1}{2}(\alpha-\alpha')}\left\{1+\frac{1}{12}\left(\frac{s}{a}\right)^2\sin^2\tfrac{1}{2}(\alpha+\alpha')\,(1+e^2)\cos(u+u')\right\}$$

where the last factor, involving the reduced latitudes, is nearly=1. For the sake of simplicity the length and azimuths of the geodetic line, Nantucket–Manomet, and also of Sebattis–Farmington, were computed. To obtain this Bessel gives three fundamental equations, (Astronomische Nachrichten, No. 3,) but it may be had by the formula,

$$\tan B=\frac{b\sin A}{c-b\cos A},\ \text{and}\ a=\frac{c-b\cos A}{\cos B}$$

where b, c, and A are given, (see Struve, in Computation of Russian Arc, Vol. 1, p. 246.) To pro-

* Bessel, Astronomische Nachrichten, No. 331, pp. 309-310.

† See, also, the form $S=s\frac{\sin\frac{1}{2}(\alpha'-\alpha)}{\sin\frac{1}{2}(\alpha'+\alpha)}\left(1+\frac{\theta^2}{12}\cos^2\frac{\alpha'-\alpha}{2}\beta\right)$, where $\beta=1+\frac{3e^2}{1-e^2}\cos^2\lambda$, in the British Ordnance Survey, by Lieutenant Colonel James; London, 1858; p. 248. The azimuth angles are to be taken within the polar triangle.

ceed from the spherical to the plane triangle, Legendre's principle is employed in either case. The results are:

Nantucket–Manomet, log. distance=[4.9076543]; forward azimuth=150° 45′ 06″.206; reverse azimuth=330° 26′ 07″.610.

Sebattis–Farmington, log. distance=[4.7705477]; forward azimuth=173° 25′ 24″.660; reverse azimuth=353° 21′ 50″.121.

Results by third method:

Nantucket–Manomet	70429m.534
Manomet–Thompson	76002m.116
Thompson–Agamenticus	67971m.699
Agamenticus–Independence	59535m.576
Independence–Sebattis	42718m.180
Sebattis–Farmington	58567m.209
Total arc	375224m.314

Fourth method.—The two preceding methods involve, directly or indirectly, the latitude and longitude computations depending upon a particular ellipsoid. This last method is independent of this process and involves nothing further than the spherical excess of any hypothesis bearing upon the earth's figure. Bessel has developed a system of polar coördinates, and applied them in his *Gradmessung* in Prussia;* in this he was followed by Struve, in the computation of the Russian arc. By the formula previously given for the solution of spherical triangles, two sides and the included angle being given, the geodetic lines from Nantucket to each of the stations were successively computed. In the larger triangles the second term of the spherical excess, $\frac{\varepsilon}{24\,r^2}(a^2+b^2+c^2)$, becomes sensible, and was introduced. The distances from Nantucket being thus known, the difference of parallels may be found by a resolution of the polar triangles. In the present case, I have computed the whole arc in order to obtain an independent check. The distances and azimuths of the computed lines are as follows:

Nantucket to Indian	49486m.517	Azim. 108° 00′ 24″.298
" " Manomet	80845m.208	150° 45′ 06″.206
" " Thompson	155065m.54	160° 59′ 38″.866
" " Agamenticus	219634m.21	167° 39′ 42″.489
" " Independence	274459m.56	176° 32′ 18″.155
" " Sebattis	316670m.88	180° 31′ 23″.070
" " Mt. Blue	382038m.50	177° 17′ 35″.081
" " Farmington	375245m.43 [5.5743154]	179° 24′ 21″.328

To find the reverse azimuth we use the fundamental relation $\frac{\sin \alpha'}{\sin \alpha}=\frac{\cos u}{\cos u'}$, (derived from Clairaut's theorem,) where $\tan u=\frac{b}{a}\tan \varphi$, and $\tan u'=\frac{b}{a}\tan \varphi'$.

Struve, by computing an auxiliary quantity, $\eta=\log\left[1-(1-\rho^2)\sin^2\varphi\right]^{-\frac{1}{2}}$, (Russian Arc, Vol. 1, p. 308,) and tabulating the same, renders the use of this formula very convenient. Extending his table to include our latitudes we have:

For latitude 41°	η=0.0006247	$\triangle\eta$=0.000253, and if we were to substitute Clarke's for Bessel's ellipsoid, $\triangle\eta$=0.000258 very nearly.
42°	6500	
43°	6753	
44°	7006	
45°	7259	

We then have:

$$\mu=(\log\cos\varphi-\log\cos\varphi')+(\eta-\eta')$$

$$\log\sin\alpha'=\log\sin\alpha+\mu$$

which gives, for our reverse azimuth, Farmington–Nantucket, 359° 22′ 20″.908. This value is

* See, also, Astronomische Nachrichten, No. 3.

checked by our formula for difference of azimuth, dZ, (Coast Survey Report of 1860, p. 361,) which gives the same result exactly. We now compute the difference of parallels by the formula

$$S = s\frac{\cos\frac{1}{2}(a+a')}{\cos\frac{1}{2}(a-a')}$$

since the line is nearly meridional, and find 375224^{m}.05.

The results found by methods second, third, and fourth may be taken as identical, that of the third method being, perhaps, numerically‡ the more accurate, has been adopted.

ACCURACY OF THE PRECEDING RESULTS.

The uncertainty in the linear distances of the 1^{ry} $\triangle$'n was found to equal its $\frac{1}{288000}$ part, (Coast Survey Report for 1865, p. 195,) which produces a probable error of $\pm 1^{m}.30$ in the length of our arc.

To ascertain the uncertainty in the arc due to an uncertainty in the standard azimuth, we have the following table of station-errors in azimuth, (A.—G.,) and of the probable errors of observation:

	A.—G.	Prob. error of obs'n.	
Indian	−4″.75	±0″.45	
Shootflying	+3″.08	0″.29	
Copecut*	+1″.04	0″.34	
Blue Hill*	−1″.27	0″.27	
Thompson	−0″.12	0″.45	
Agamenticus	−2″.15	0″.38	
Independence	−1″.55	0″.25	
Cape Small	+1″.95	0″.38	
Pleasant*	+2″.72	0″.38	
Sebattis	+1″.08	0″.34	Σ(A.—G.)=0

The station-error in azimuth greatly exceeds the error of observation, and the probable error, ±0″.52, of the standard azimuth (Shootflying to Manomet, 143° 3′ 19″.657) for the arc is almost wholly due to the effect of local deviation of the zenith. An uncertainty of ±0″.52 in the azimuth produces a corresponding uncertainty of $\pm 0^{m}.01$ in the length of the arc.

If we were to omit the three stations marked with an asterisk, on account of their greater distance from the arc, the above standard azimuth would only change by 0″.35, which is within the probable error.

The uncertainty in the arc, arising from the uncertainty in the standard latitude, (Thompson, 42° 36′ 40″.238,) may be ascertained by means of the station-errors in latitude,† which are given in the following table:

No.	Station.	Geodetic latitude.	Reduction to Thompson.	Astronomical latitude.	Astronomical latitude referred to Thompson.	Station error.
		° ′ ″	° ′ ″	° ′ ″ ″	″	″
1	Nantucket	41 17 33.660	+1 19 06.578	41 17 32.86 ± 0.06	39.44	−0.50
2	Manomet	41 55 36.772	+ 41 03.466	41 55 35.33 ± 0.05	38.80	−1.14
3	Thompson	42 36 40.238	0.000	42 36 38.28 ± 0.10	38.28	−1.66
4	Isles of Shoals*	42 59 13.304	− 22 33.066	42 59 12.88 ± 0.09	39.81	−0.13
5	Agamenticus	43 13 23.158	− 36 42.920	43 13 24.98 ± 0.07	42.06	+2.12
6	Independence	43 45 32.466	−1 08 52.228	43 45 34.43 ± 0.06	42.20	+2.06
7	Cape Small*	43 46 41.925	−1 10 01.687	43 46 43.48 ± 0.04	41.79	
8	Sebattis	44 08 36.678	−1 31 56.440	44 08 37.60 ± 0.09	41.16	+1.22
9	Farmington	44 40 14.313	−2 03 34.075	44 40 12.06 ± 0.05	37.98	−1.96
						Σ (A.—G.) = 0.

‡ Using seven places of decimals.

† The astronomical results, for latitude, as at first reported, are now corrected to accord with the best available star-places. April, 1869.

The mean astronomical latitude, when referred to Thompson, is 42° 36′ 39″.94. Nos. 6 and 7 being in nearly the same latitude were united in one result, (42″.00,) as indicated by brackets. Subtracting this mean value from each of the referred latitudes, we find the station-error in latitude at each place as given in the last column of the above table. The probable error of the mean astronomical latitude is $\pm 0''.32$, which is almost wholly due to the effects of local attractions. By omitting the stations Isles of Shoals and Cape Small, our results are not sensibly affected. An uncertainty of $\pm 0''.32$ in the mean latitude produces an uncertainty of less than $\pm 0^{m}.01$ in the length of the arc.

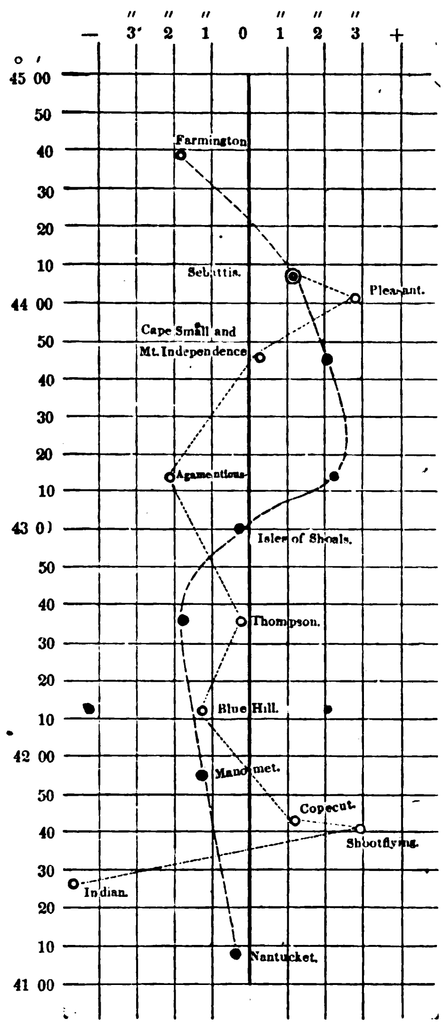
The probable error in the deduced length of our arc is, consequently, $\pm 1^{m}.30$.*

The accompanying diagram shows the station-errors in latitude and in azimuth. The latitude deflection apparently consists of a large wave of disturbance, which continues through a considerable longitudinal extent, as found by other stations, and covers so great a length of the arc as to become a source of uncertainty in the utilization of the arc for combinations with others. Owing to this extended development of a systematic deviation from a regular figure, it is desirable that the arc be extended northward until this disturbing influence is passed; the smaller wrinkles of latitudinal deflection are more nearly of a size comparable with the probable error of the observed latitudes.

The unit of length in which the linear measures are given is the committee meter of the Philosophical Society of Philadelphia, which was compared, (August 24, 1867,) at Paris, directly with the standard *platinum meter of the Conservatoire des Arts et Metiers*, and was found (at the temperature of melting ice) $=1^{m}.00000336$ of the *platinum meter of the Archives*. To express, therefore, our linear results in terms of that meter, they require an increase of their $\frac{1}{297619}$ part, or of nearly their three-hundred-thousandth part, and their logarithms require the addition of 0.0000014 6, or of 15 nearly, in the seventh place of decimals.

The geodetic operations were executed by the late Superintendent, Professor A. D. Bache, or under his personal direction.

Local deflection.



Local deflection in latitude ●.
Local deflection in azimuth ○.

DETERMINATION OF THE ASTRONOMICAL LATITUDES.

The astronomical latitudes were chiefly ascertained by means of the zenith telescope, in addition to which the zenith sector was employed at two stations, and at a third a transit in the prime vertical.

No.	Name of station.	Instrument.	Observers.	Date.
1	Nantucket Cliff	Zenith telescope No. 5	C. O. Boutelle F. H. Agnew	November and Dec'r, 1866.
2	Manomet	do	C. O. Boutelle F. H. Agnew	July and August, 1867.
3	Thompson	Zenith telescope Military Academy	T. J. Lee, T. E. R. H. Fauntleroy	September and Oct'r, 1846.
4	Agamenticus	do	T. J. Lee, T. E.	September and Oct'r, 1847.
		Zenith sector No. 1	A. D. Bache C. O. Boutelle R. H. Fauntleroy	October and Nov'r, 1847.
		Transit No. 2	A. D. Bache G. Davidson R. H. Fauntleroy	October and Nov'r, 1847.
5	Mount Independence	Zenith telescope No. 2	G. W. Dean	September and Oct'r, 1849.
		Zenith sector No. 1	A. D. Bache G. Davidson	September and Oct'r, 1849.
6	Sebattis	Zenith telescope No. 1	J. E. Hilgard	June and July, 1853.
7	Farmington	Zenith telescope No. 5	C. O. Boutelle F. H. Agnew	October and Nov'r, 1866.

The stations Nos. 3, 4, 5, and 6 were occupied under the immediate direction of the late Superintendent.

The following comparison of results of latitudes obtained by different methods and instruments indicate that the astronomical latitudes may generally be relied on within the probable error, as derived from the observations themselves. The micrometric measures with the zenith telescope developed a certain dependence of the results on the zenith distance, which can only be attributed to systematic defects in the assigned declinations of stars. This variation is confined within narrow limits, and is also corroborated by the results obtained with the zenith sector; the differences of astronomical latitudes, however, are not sensibly affected:

Latitude of Agamenticus by zenith telescope - - -	$43^\circ\ 13'\ 24''.89 \pm 0''.11$
zenith sector - - -	$25''.07 \pm 0''.10$
transit in prime vertical -	$24''.97 \pm 0''.14$
Latitude of Mt. Independence by zenith telescope - -	$43^\circ\ 45'\ 34''.29 \pm 0''.08$
zenith sector - -	$34''.56 \pm 0''.08$

The following is a recapitulation of the geodetic and astronomical results of the measurement of the Nantucket arc of the meridian, the correction for excess in length of the unit of measure having been applied

RECAPITULATION OF RESULTS.

Stations.	Observed astronomical latitudes.	Measured difference of parallels.	Length of meridional arcs.
	° ′ ″ ″	*Meters.*	*Meters.*
Nantucket Cliff......	41 17 32.86 ± 0.06		0.00
		70429.77	
Manomet	41 55 35.33 ± 0.05		70429.77
		76002.37	
Thompson	42 36 38.28 ± 0.10		146432.14
		67971.93	
Agamenticus	43 13 24.98 ± 0.07		214404.07
		59535.58	
Mount Independence.	43 45 34.43 ± 0.06		273939.65
		42718.32	
Sebattis	44 08 37.60 ± 0.09		316657.97
		58567.41	
Farmington..........	44 40 12.06 ± 0.05		375225.38

The total length of arc, in meters, 375225.38 ± 1.30.

The six partial arcs give the following values for the length of 1′, viz:

Between Nantucket and Manomet - - - - - - -	$1851^m.4$
Manomet and Thompson - - - - - - -	$1851^m.5$
Thompson and Agamenticus - - - - - -	$1848^m.2$
Agamenticus and Mt. Independence - - - - -	$1851^m.4$
Mt. Independence and Sebattis - - - - - -	$1853^m.1$
Sebattis and Farmington - - - - - -	$1854^m.9$
For the whole arc - - - - -	$1851^m.6 \pm 0^m.6$

Hence a degree in the middle latitude of the arc will be nearly 111,096 meters in length, with an uncertainty of ±36 meters.

APPENDIX No. 10.

ADDENDA TO APPENDIXES No. 9 AND No. 11 OF THE COAST SURVEY REPORT OF 1866.

PREPARED BY CHARLES A. SCHOTT, ASSISTANT IN CHARGE OF COMPUTING DIVISION.

1. *To* (4) *Appendix No.* 9, *on the determination of time by means of the transit instrument.*

The observer will always find it convenient to prepare a working ephemeris to contain, for the locality and time proposed for observing, the stars selected, their position, magnitude, right ascension, (to which the clock correction on each night can readily be applied,) and setting on the finders for illumination west and east, according to the graduation of the circle or circles of his instrument. He will do well to start the clock at such a time as to indicate, as nearly as may be, sidereal time, and to regulate the rate in order to make it as small as possible. The following ephemeris may serve as a specimen:

SPRINGFIELD, ILLINOIS, *August*, 1869.

$\phi = 39° 49'$ $\lambda = 89° 38'$

Star.	Position.	Culmination.	Magnitude.	α	δ	Setting. Lamp W. Zen. dist.	Setting. Lamp E. Altitude.
				h. m. s.	° ′	° ′	° ′
Groombridge, 2320	......	U.	5.6	16 05 58	+ 68 09	61 40	28 20
δ Ophiuchi	S.	......	3	07 29	− 3 21	43 10	46 50
τ Herculis	N.	......	3.4	15 48	+ 46 38	83 11	6 49
α Scorpii	S.	......	1.2	21 23	− 26 08	65 57	24 03
η Draconis	N.	......	2.3	16 22 14	+ 61 49	68 00	22 00
15 Draconis	......	U.	5.3	28 15	+ 69 03	60 46	29 14
ζ Ophiuchi	S.	......	2.3	29 57	− 10 18	50 07	39 53
η Herculis	S.	......	3	38 24	+ 39 10	0 39	89 21
α Camelopardalis	......	L.	4	41 02	+ 66 07	15 56	74 04
κ Ophiuchi	S.	......	3.4	16 51 28	+ 9 35	30 14	59 46
d Herculis	S.	......	5	56 46	+ 33 46	6 03	83 57
ε Ursæ Minoris	......	U.	4.5	59 29	+ 82 15	47 34	42 26
α¹ Herculis	S.	......	Var.	17 08 41	+ 14 32	25 17	64 43
b Ophiuchi	S.	......	5	18 22	− 24 03	63 52	26 08
Groombridge, 966	......	L.	6.7	17 22 14	+ 74 57	24 46	65 14
β Draconis	N.	......	2.3	27 28	+ 52 24	77 25	12 35
α Ophiuchi	S.	......	2	28 51	+ 12 39	27 10	62 50
ω Draconis	......	U.	5	37 43	+ 68 49	61 00	29 00
μ Herculis	S.	......	3.4	41 19	+ 27 48	12 01	77 59
ψ¹ Draconis, (pr.)	......	U.	4.5	17 44 16	+ 72 13	57 36	32 24
γ Draconis	N.	......	2.3	53 34	+ 51 30	78 19	11 41
γ² Sagittarii	S.	......	3.4	57 23	− 30 25	70 14	19 46
22 Camelopardalis	......	L.	4.5	18 04 24	+ 69 22	19 11	70 49
μ¹ Sagittarii	S.	......	4	05 56	− 21 05	60 54	29 06
&c.							

To (5). *Example of record and computation of inequality of pivots.*

Let B and B′ designate the inclination, as given by the level readings, for clamp W. and E., respectively; b and b' the same, when corrected for pivot inequality p; then

$$p=\frac{B'-B}{4} \text{ and } \begin{cases} b=B+p \text{ for clamp W.,} \\ b=B-p \text{ for clamp E.,} \end{cases}$$

supposing the V bearings of instrument and level to have the same angular opening and the pivots to be circular in form.

Observations for inequality of pivots of Transit No. 4.

Station, Seaton, Washington—G. W. D., observer—June 19, 1867.

Altitude.	Time.	Temperature, Fah.	CLAMP WEST. Object glass S. Level. W. end.	E. end.	$\frac{1}{4}(\Sigma w-\Sigma e)$ B	CLAMP EAST. Object glass N. Level. W. end.	E. end.	$\frac{1}{4}(\Sigma w-\Sigma e)$ B′	$\frac{B'-B}{4}=p$
°	h. m.	°	d.	d.	d.	d.	d.	d.	d.
55	10 30 a. m.	73	60.0	64.0	+0.600	59.0	65.2	−0.425	−0.256
			65.2	58.8		64.0	59.5		
50	45 a. m.	72	65.0	59.0	+0.950	64.0	59.5	−0.250	−0.300
			60.8	63.0		59.0	64.5		
45	50 a. m.	72.5	60.8	63.0	+1.450	59.5	64.0	−0.125	−0.394
			66.0	58.0		64.0	60.0		
40	11 00 a. m.	72.8	65.0	58.8	+1.050	64.0	60.0	−0.175	−0.306
			61.0	63.0		59.3	64.0		
35	05 a. m.	73	60.5	63.0	+1.200	59.2	64.0	−0.575	−0.444
			65.5	58.2		63.0	60.5		
30	15 a. m.	73.2	63.5	58.0	+1.000	63.0	60.5	−0.125	−0.281
			60.5	62.0		60.0	63.0		
25	20 a. m.	73.8	60.5	62.0	+1.125	59.0	63.0	−0.125	−0.312
			64.0	58.0		62.5	59.0		
20	30 a. m.	74	62.0	57.5	+1.500	62.0	59.0	0.000	−0.375
			60.8	59.3		59.0	62.0		
15	40 a. m.	74.5	60.0	60.0	+1.375	58.0	61.0	−0.125	−0.375
			62.5	57.0		60.5	58.0		
10	50 a. m.	75	62.0	57.0	+1.750	60.5	58.0	0.000	−0.437
			60.0	58.0		58.0	60.5		
5	12 00 m.	76	58.5	59.0	+1.250	58.0	60.5	−0.125	−0.344
			61.5	56.0		59.0	57.0		
0	10 p. m.	76	60.0	57.0	+0.875	59.0	57.0	0.000	−0.219
			58.5	58.0		57.0	59.0		

Value of 1 division of level = 1″.05.

$$\text{Mean } p=-0^{d}.337\pm0^{d}.013$$
$$=-0^{s}.024\pm0^{s}.001$$

for position, clamp W., the value $+b$, as found by the level, must therefore be diminished numerically; and for position, clamp E., it must be numerically increased to allow for inequality of pivots. Irregularities in the figure of the pivots will appear by successive level readings for every 10° of zenith distance, north and south, and, by comparing with the mean of all readings, a correction can be deduced for any given position of the telescope and clamp. When the transit instruments are accompanied by a hanging level, (as in the meridian telescope,) the pivots may be tested for any zenith distance; instruments not provided with such a level may sometimes be tested by unscrewing the tubes carrying the object and eye lenses.

Specimen of record for value of one division of level by means of a level trier.

Coast Survey Office, December 8, 1868—Determination of value of 1 division of level B belonging to Transit No. 6—Value of 1 division of level trier = 0″.99—A. T. M., Observer.

	Level trier, forward.	Level B.		Change for +10*d.* of trier.	Temperature.	Temperature.	Level trier, backward.	Level B.		Change for 10*d.* of trier.	
		+R	L					+R	L		
h. m.		*d.*	*d.*	*d.*	°	°		*d.*	*d.*	*d.*	*h. m.*
12 39	210	91.5	9.0		62.5	62.5	210	90.5	6.0		1 04
				10.75						12.50	
	220	80.5	19.5				220	78.0	18.5		
				12.00						12.25	
	230	68.5	31.5				230	66.0	31.0		
				11.25						10.00	
	240	57.0	42.5				240	56.0	41.0		
				9.25						10.00	
	250	47.5	51.5				250	46.0	51.0		
				9.00						8.50	
	260	38.5	60.5				260	37.5	59.5		
				9.25						9.00	
	270	29.0	69.5				270	28.5	68.5		
				8.75						8.50	
	280	20.0	78.0				280	20.0	77.0		
				8.75						9.25	
12 52	290	11.0	86.5		62.5	62.5	290	11.0	86.5		12 52

Difference of level trier.	Corresponding difference of level B.		
	Forward.	Backward.	
	d.	*d.*	
40	43.25	44.75	
30	32.50	32.25	
20	20.50	20.00	
10	9.25	10.00	400 div. = 389*d.*75 of B = 396″ } on the average.
10	9.00	8.50	1*d.* of B = 1″.02 } on the average.
20	18.25	17.50	
30	27.00	26.00	
40	35.75	35.25	
200	195.50	194.25	

The above level is evidently irregular, its curvature being different at different parts and flattest near the marked end. For the portion of the scale near the middle, and ordinarily used, we obtain the value 1″.08, derived from 40 divisions of trier, =36.75 div.

The observations should be made at different and extreme temperatures, in order to ascertain whether the curvature changes materially. When the level is furnished with a chamber, the bubble, during ordinary observations, should be kept at nearly the same length which was given to it in the experiments for value of level-scale.

To (6). *Tabulation of factors.*

The reduction of transits will be facilitated by a tabulation of the factors A, B, C, (as taken from the general tables,) and it will be noted that A will be + except for stars between the zenith and pole; B will be + except for stars at lower culmination; and C will be + except for stars at lower culmination; or B and C will have the same sign.

Table of star constants.

Springfield, Ill., 1869.

		A	B	C	A^2	C^2	AC
Groombridge, 2320	U.	— 1.27	+ 2.36	+ 2.69	1.61	7.24	— 3.42
δ Ophiuchi	......	+ 0.68	+ 0.73	+ 1.00	.46	1.00	+ .68
τ Herculis	......	— 0.18	+ 1.45	+ 1.45	.03	2.10	— .26
α Scorpii	......	+ 1.02	+ 0.45	+ 1.11	1.04	1.23	+ 1.13
η Draconis	......	— 0.80	+ 1.96	+ 2.12	.64	4.49	— 1.70
15 Draconis	U.	— 1.36	+ 2.44	+ 2.79	1.85	7.78	— 3.79
ζ Ophiuchi	......	+ 0.78	+ 0.65	+ 1.02	.61	1.04	+ .80
η Herculis	......	+ 0.02	+ 1.29	+ 1.29	.00	1.66	+ .03
α Camelopardalis, &c	L.	+ 2.37	— 0.68	— 2.47	5.62	6.10	— 5.85

C and A C change sign by reversal of instrument.

To (9) *of Appendix No.* 11 *of Report of* 1866, *on the astronomical determination of an azimuth.*

In planning work for observing an azimuth, according to the requirements of the case, the power and construction of the instrument, and the convenience of the observer, the following tables of the times of the culminations and elongations of four circum-polar stars will be found a useful auxiliary. These tables will give the times to the nearest minute for the first day of each month and for the year 1873, supposing the observer's position in latitude 40° N. and in west longitude 6^h from Greenwich, and by an easy interpolation they will give the times for any day of the year, for any year, (within this century,) and for any north latitude between 30° and 50°. The times are given according to astronomical accounts, reckoning from noon of the civil day.

Mean local time (astronomical) of the elongations and culminations of four circum-polar stars, for 1873, *and lat.* 40°, *long.* 6^h *west of Greenwich.*

1st.	α Ursæ Minoris.				λ Ursæ Minoris.			
	E. E.	U. C.	W. E.	L. C.	E. E.	U. C.	W. E.	L. C.
	h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
Jan'y.	0 30.8	6 25.2	12 19.7	18 23.3	19 05.0	1 04.4	6 59.8	13 02.4
Feb'y.	22 24.6	4 23.0	10 17.4	16 21.0	17 03.0	22 58.4	4 57.8	11 00.4
March.	20 34.1	2 32.5	8 26.9	14 30.5	15 13.1	21 08.6	3 08.1	9 10.5
April.	18 32.1	0 30.4	6 24.8	12 28.4	13 11.8	19 07.2	1 06.5	7 09.1
May.	16 34.3	22 28.7	4 27.1	10 30.7	11 14.3	17 09.7	23 05.1	5 11.7
June.	14 32.7	20 27.1	2 25.5	8 29.1	9 12.9	15 08.3	21 03.7	3 10.3
July.	12 35.1	18 29.7	0 27.9	6 31.5	7 15.1	13 10.5	19 06.0	1 12.5
Aug't.	10 33.7	16 28.2	22 22.6	4 30.1	5 13.0	11 08.5	17 04.0	23 06.5
Sept'r.	8 32.1	14 26.6	20 21.1	2 28.5	3 10.8	9 06.2	15 01.6	21 04.2
Oct'r.	6 34.4	12 28.8	18 23.3	0 30.8	1 12.3	7 07.7	13 03.1	19 05.7
Nov'r.	4 32.5	10 27.0	16 21.4	22 25.0	23 05.8	5 05.1	11 00.5	17 03.1
Dec'r.	2 34.4	8 28.8	14 23.2	20 26.8	21 07.1	3 06.5	9 02.0	15 04.5

1st.	51 Cephei.				δ Ursæ Minoris.			
	E. E.	U. C.	W. E.	L. C.	E. E.	U. C.	W. E.	L. C.
	h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
Jan'y.	6 03.0	11 52.8	17 42.5	23 50.8	17 35.7	23 23.4	5 14.9	11 25.3
Feb'y.	4 01.1	9 50.9	15 40.6	21 48.9	15 33.9	21 21.6	3 13.2	9 23.6
March.	2 10.9	8 00.7	13 50.4	19 58.7	13 43.9	19 31.6	1 23.2	7 33.6
April.	0 08.8	5 58.5	11 48.3	17 56.6	11 42.2	17 29.8	23 17.6	5 31.8
May.	22 06.8	4 00.4	9 50.2	15 58.5	9 44.4	15 32.0	21 19.7	3 34.0
June.	20 04.7	1 58.4	7 48.1	13 56.4	7 42.6	13 30.3	19 17.9	1 32.2
July.	18 06.9	0 00.4	5 50.2	11 58.4	5 44.7	11 32.3	17 20.2	23 30.5
		23 56.5						
Aug't.	16 05.1	21 54.8	3 48.4	9 56.7	3 42.6	9 30.2	15 18.0	21 28.4
Sept'r.	14 03.4	19 53.1	1 46.7	7 55.0	1 40.5	7 28.2	13 15.9	19 26.3
Oct'r.	12 05.6	17 55.4	23 45.1	5 57.3	23 38.5	5 30.1	11 17.7	17 28.1
Nov'r.	10 04.0	15 53.8	21 43.5	3 55.7	21 36.4	3 27.9	9 15.7	15 26.1
Dec'r.	8 06.3	13 56.0	19 45.8	1 58.0	19 38.3	1 29.9	7 17.5	13 27.9

1. To correct the tabular times so as to apply to any year subsequent to 1873:

Add, in the case of Polaris	$0^m.35$	for every year.
Subtract, in the case of λ Ursæ Minoris	$1^m.0$	for every year.
Add, in the case of 51 Cephei	$0^m.5$	for every year.
Subtract, in the case of δ Ursæ Minoris	$0^m.3$	for every year.

2. To correct the times for any year in a quadriennium:

For first year after a leap-year the table is perfect.

For second year after a leap-year add	$1^m.0$	
For third year after a leap-year add	$2^m.0$	
For leap-year and before March 1 add	$3^m.0$	For the remainder of the year subtract $1^m.0$.

3. To allow for difference of latitude between the limits of 30° and 50°, correct the times of elongations as follows:

For Polaris, add $0^m.15$	for each degree south of 40°, and	subtract $0^m.19$	for each degree north of 40°.
For λ U. Min., add $0^m.11$		subtract $0^m.15$	
For 51 Ceph., add $0^m.29$		subtract $0^m.39$	
For δ U. Min., add $0^m.35$		subtract $0^m.48$	

To follow (13): (13½). ***Observations with a transit instrument in the vertical of a close circumpolar star, near its elongation.***

If a transit instrument only is available, and a mark can be placed in the vertical of the elongation, the method (see Coast Survey Report of 1856, Appendix No. 27) of measuring the azimuthal angle between the mark and a close circumpolar star at elongation by means of the micrometer-screw which moves one of the V bearings in azimuth may be applied with results possessing a considerable degree of accuracy. To secure this it is, however, essential that the sum of the positive and negative micrometer measures balance, (the mark being placed, for this reason, a little inside the vertical of the elongation,) in which case an inequality in the value of a division at different positions of the screw will not affect the result; further, the measures should be small, since the V supports of the axis are not pivoted, and any considerable motion must roll and elevate the axis, changing its bearings. The collimation is eliminated by reversals. The level correction may be found with sufficient precision by $\frac{d}{4}[(w+w')-(e+e')]\tan\varphi$, (see Art. 13;) and the value of a division of the pivot-micrometer is found by means of successive transits of the star near culmination over the same thread, for equidistant micrometer divisions by the formula

$$A=\frac{\sin p \sec(\varphi \pm p)}{\sin 1''}\sin t$$

where the sign $\pm$ is to be used for upper and lower culmination, but generally the azimuthal value, expressed in seconds of arc, may be found with sufficient precision by the formula

$$15 \sin p \sec h \,.\, t$$

where p=the polar distance h the altitude and t the hour-angle in seconds of time. The reduction to elongation and the correction for diurnal aberration are the same as in Art. 13.

Example of record and reduction.

Station, Cat Island, Mississidpi—Polaris near western elongation—December 5, 1855—Observer, J. E. H.—Instrument, 26-inch transit, by Würdemann, C. S. No. 9.

SET No. 4.

Object.	Lamp.	Chr. time.	Microm.	Level. W.	Level. E.	Remarks.
		h. m. s.	t. d.	W.	E.	
Mark	E.	7 16	1 86.0			Chr. time of elongation, 7h. 06m. 00s. 2. Rate of chr. small. Chr. 220 fast at time of W. El., 2m. 30s. 0.
			85.1			
			86.8	×30.5	30.5	
Polaris		7 18 59.5	1 77.8	30.5	30.5×	
		19 21.5	77.2			
		19 47.0	77.2			
	W.	7 21 55.5	1 75.3			
		22 16.5	75.9			
		22 45.5	75.0	30.0	31.0×	
Mark		....	1 87.0	×31.5	29.5	
			86.0			
		7 25	87.0			

Increase of micrometer readings corresponds to movement of telescope from north to west, 1 div. of level $=2''.0$. The value of 1 div. of micrometer is found from the following record:

Micr.	Chr. time.	Diff. from mean.	Polaris near U. C.
			$\phi=30^\circ\ 14'\ 22''$
t. d.	h. m. s.	h. m. s.	$p=1^\circ\ 27'\ 15''$
1 50	1 04 52.0	0 02 00.7	90 div. correspond to 439s. 0
60	05 39.0	01 13.7	1 div. corresponds to 4s. 8778
70	06 27.5	00 25.2	log t 0.68822
80	07 16.5	00 23.8	log 15 .... 1.17609
90	08 07.5	01 14.8	log sin p 8.40444
2 00	08 53.5	02 00.8	log sec 31° 41′....... 0.07009
			0.33884
Mean 1 75	1 06 52.7	Sum 07 19.0	Value of 1 div. of pivot micr.$=2''.182$

The azimuth is deduced as follows:

Time from elong'n.	Red'n to elong'n.	Mean readings.			
m. s.	″			t. d.	
12 59.3	−9.7	Mark	Lamp E.	1 85.97	1 86.32
13 21.3	10.3		Lamp W.	1 86.67	
13 46.8	11.0				
15 55.3	14.6	Star	Lamp E.	1 77.40	1 76.40
16 16.3	15.3		Lamp W.	1 75.40	
16 45.3	16.2				
Mean............	−12.85	Difference			9.92=21″.65

Mark west of star	$+21''.65$
Correction for level	$-\ 0''.15$
Reduction to elongation	$-12''.85$
Mark west of star at elongation	$+\ 8''.6$
Azimuth of Polaris at west elongation	$1^\circ\ 41'\ 00''.2$
Mark west of apparent north	$1^\circ\ 41'\ 08''.8$
Correction for diurnal aberration	$-\ 0''.3$
Mark west of north	$1^\circ\ 41'\ 08''.5$

To follow (18): ($18\frac{1}{2}$)*a*. ***Observations with a transit instrument of a close circumpolar star, near culmination.***

If a transit instrument is fitted with an eye-piece micrometer, (movable vertical thread,) and if a meridian-mark can be established, its azimuth may be determined with great precision by micrometric measures of the mark and the star when culminating. In this case the time must be determined with precision, and, as the method admits of stars being observed above and below the pole, the effect of a small error in time or in the star's right ascension may be eliminated or greatly reduced. The mark should be at a distance sufficient to require no change in the sidereal focus of the telescope. The chronometer correction is found by the ordinary transit observations; in those for azimuth proper, the vertical thread of the micrometer is set in advance of the star successively by equal divisions or turns of the screw, and the transits are recorded by the eye and ear or by the use of a chronograph. The value of a division of the micrometer is found from the azimuth observations themselves.

Let t=time of transit of a culminating polar star, corresponding to one turn of micrometer converted into arc, then 1 turn$=\frac{\cos\delta\sin t}{\sin 1''}$. The level correction (in time) is found by the formula $b\,\mathrm{B}$, where $b=\frac{1}{15}\cdot\frac{d}{4}[(w+w')-(e+e')]$ and $\mathrm{B}=\cos(\varphi-\delta)\sec\delta$. For lower culmination take $180^\circ-\delta$, instead of δ, or else reverse the sign of δ; if the level correction, however, is not applied to the times prior to computing the azimuthal deviation, it may be applied after it, using the formula $i''\cot\zeta$, where i=the inclination of the axis in seconds of arc $\left\{\begin{matrix}+\\-\end{matrix}\right\}$ for $\left\{\begin{matrix}\text{east}\\\text{west}\end{matrix}\right\}$ end high.

The collimation correction is found by subtracting the mean reading of micrometer, for lamp west and east, on the mark, from the mean micrometer reading on the star, and by converting this difference into seconds of time. (See determination of the value of micrometer.) The sign of the correction follows from the appearance of the record.

To obtain the hour-angle of the star, we have

T=observed chronometer time + $\triangle$ T + level correction + collimation correction and the hour-angle

$$t=\alpha-\mathrm{T};$$

hence, the azimuthal effect

$$\mathrm{A}=\frac{\sin p\sec(\varphi\pm p)\sin t}{\sin 1''}\quad\left\{\begin{matrix}+\\-\end{matrix}\right\}\text{ for }\left\{\begin{matrix}\text{upper}\\\text{lower}\end{matrix}\right\}\text{ culmination.}$$

To the azimuth of the star thus referred to the line of collimation of the instrument, we add, algebraically, the difference of the micrometer readings of star and mark and convert the same into seconds of arc. The signs are readily found from the positions in each particular case.

The method is much simplified by observing each star with lamp east and lamp west, reversing at the middle of the pointings.

To (18½) *a.* ***Example of record and computation.***

Station, Depot Key, Fla.—March 20, 1852.—δ Ursæ Min. at L. C., and 51 Cephei at U. C.—Observer, J. E. H.—Instrument, the Simms Transit, C. S. No. 8.

Time by 202.	Mark. Lamp E.	Mark. Lamp W.	Time by 202.	Chr. time by 202.	δ Ursæ Min.	Chr. time by 202.	51 Cephei.
h. m.	t. d.	t. d.	h. m.	h. m. s.	t. d.	h. m. s.	t. d.
5 20	18 76.0	12 67.0	5 40	6 18 44	18 22	6 27 34	13 22
	76.0	66.5		19 11	17 72	28 08	13 72
	75.0	67.0		19 37.5	17 22	28 40.5	14 22
	76.0	66.5		20 04.5	16 72	29 15	14 72
	75.0	67.5		20 31.5	16 22	29 48	15 22
	75.0	67.5		20 59	15 72	30 22	15 72
	75.1	67.0		21 25.5	15 22	30 54	16 22
	75.1	67.2		21 52	14 72	31 29	16 72
	75.8	67.0		22 19	14 22	32 01.5	17 22
5 30	75.0	66.5	5 50	22 46	13 72	32 36	17 72
				23 13	13 22	33 10	18 22

Level. W.	Level. E.		Level. W.	Level. E.
48.1	49.8	1 div. of level = 1″.	63.0	38.0
63.0	35.0		49.0	53.5
48.2	50.8		63.5	39.0
63.0	36.3		49.0	53.5

Determination of the value of 1 division of the micrometer:

Mean of times, $6^h\ 20^m\ 58^s.5$ for δ Ursæ Minoris and $6^h\ 30^m\ 21^s.6$ for 51 Cephei.

Corresponding micrometer readings, $15^t\ 72^d$ for δ Ursæ Minoris and $15^t\ 72^d$ for 51 Cephei.

Hence the following differences from the mean:

m. s.	t. d.		m. s.	t. d.	
2 14.5	2 50	From obs. of δ Urs. Min.:	2 47.6	2 50	From obs. of 51 Cephei:
1 47.5	2 00	1 div. corresponds to 0s.5383	2 13.6	2 00	1 div. corresponds to 0s.6703
1 21.0	1 50	log 15 1.17609	1 41.1	1 50	log 15 1.17609
0 54.0	1 00	log t 9.73102	1 06.6	1 00	log t 9.82627
0 27.0	0 50	log cos δ 8.77395	0 33.6	0 50	log cos δ 8.67961
0 00.5	0 00	9.68106	0 00.4	0 00	9.68197
0 27.0	0 50		0 32.4	0 50	
0 53.5	1 00	1 div. = 0″.4798	1 07.4	1 00	div. = 0″.4808
1 20.5	1 50		1 39.9	1 50	
1 47.5	2 00		2 14.4	2 00	
2 14.5	2 50		2 48.4	2 50	
Sum 807s.5	1500 divs.		1005s.4	1500 divs.	

Mean of all determinations—1 division of micrometer = 0″.4800.

$\phi = 29° 07′ 30″$ Mark, mean reading.			B = −7.30 δ Ursæ Minoris, L. C.		B = +11.04 51 Cephei, U. C.	
	t.	*d.*		*h. m. s.*		*h. m. s.*
Lamp E..........	18	75.4	Chronometer time......	6 20 58.46		6 30 21.64
Lamp W.........	12	67.0	Δ T....................	−51.30		−51.30
Line of collim'tion	15	71.2	Sidereal time of obs.....	6 20 07.16		6 29 30.34
Star, lamp W...	15	72.0	Corr'n for level 0.42×7.30	− 3.07	0.337×11.04 =	+ 3.72
Difference.......		0.8	Corr'n for coll. 0.8×0.538	+ 0.42	0.8×0.670 =	− 0.54
			T........................	6 20 04.51	T............	6 29 33.52
			a........................	6 20 05.61	*a*............	6 29 33.15
			a−T.....................	+ 1.10	*a*−T.........	− 0.37
Star E. of N................			A........................	− 1″.09	A............	− 0″.31
Mark E. of star.............			3*t.* 4*d.* 2 =	2 26″.02		2 26″.02
Mark E. of north..........				0° 02′ 24″.93		0° 02′ 25″.71

To which the correction for diurnal aberration is yet to be applied.

If we were to use the second formula for level correction, as directly applied to the azimuth, the computation would stand as follows:

	h. m. s.	*h. m. s.*		
Sidereal time of observation.	6 20 07.16	6 29 30.34	For δ Urs. Min.,	$i = -6''.30$; $\zeta = 64° 16′ 54″$
Correction for collimation..	+ 0.42	− 0.54	For 51 Cephei,	$i = -5''.06$; $\zeta = 58° 08′ 02″$
T′..........................	6 20 07.58	6 29 29.80		
a..........................	6 20 05.61	6 29 33.15		
a−T′.......................	− 1.97	+ 3.35		
A..........................	+ 1″.95	+ 2″.83		
Level correction $i \cot \zeta$....	− 3″.04	− 3″.14		
Mark E. of star............	2 26″.02	2 26″.02		
Mark E. of north..........	0° 02′ 24″.93	0° 02′ 25″.71		

NOTE.—At this station, also, observations were made on δ Ursæ Minoris at upper culmination and on 51 Cephei at lower culmination, and the results were combined with those from the stars in the opposite position.

Art. ($18\frac{1}{2}$)*b*. *Observations with a transit instrument of a close circumpolar star, near culmination.*

If the transit has no eye-piece micrometer, (as is usually the case with the smaller instruments,) we may still accurately observe an azimuth by means of the pivot (or V) micrometer, as in the case of Art. ($13\frac{1}{2}$), but without moving the instrument much from its meridional position. When thus observing culminations, the same precautions respecting the employment of the pivot micrometer are necessary, as already mentioned.

It is desirable for these observations that a scale be applied to the micrometer to facilitate the counting of the whole turns. In connection with this method, and considering the special appliances when the instrument is known as the meridian telescope, the transit thus becomes of great importance in geodesy, as this single instrument permits most accurate observations for time, latitude, longitude, and azimuth. Should, for the latter purpose, the ground not admit of the location of a distant meridian-mark, a collimator is recommended, consisting of any firmly mounted (and collimated) telescope, of about equal power with the transit telescope.

The value of one turn of the pivot micrometer is either found from the azimuth record or from special observations of a close circumpolar star near culmination, as in Art. ($13\frac{1}{2}$), by the formula

$$A = \frac{\sin p \sec (\varphi \pm p) \sin t}{\sin 1''}, \text{ or by } 15 \sin p \sec h \cdot t$$

and, in case t is too great to admit of the direct substitution of the arc for the sine, we can apply the correction to the observed times by means of the following table:

t	$\frac{1}{6}(15 \sin 1'')^2 t^3$	t	$\frac{1}{6}(15 \sin 1'')^2 t^3$
m.	*s.*	*m.*	*s.*
5	0.02	20	1.52
6	0.04	21	1.76
7	0.07	22	2.03
8	0.10	23	2.32
9	0.14	24	2.63
10	0.19	25	2.97
11	0.25	26	3.34
12	0.33	27	3.74
13	0.42	28	4.18
14	0.52	29	4.64
15	0.64	30	5.14
16	0.78	31	5.67
17	0.93	32	6.24
18	1.11	33	6.84
19	1.30		

The correction for level is found, as in the preceding article, $=b$B, and the azimuth of the star is computed by the formula given in the same article, viz:

$$A = \frac{\sin p \sec (\varphi \pm p) \sin t}{\sin 1''}, \qquad \left\{ \begin{matrix} + \\ - \end{matrix} \right\} \text{for} \left\{ \begin{matrix} \text{upper} \\ \text{lower} \end{matrix} \right\} \text{culmination.}$$

Example of record and reduction.

Station, West Gulf Shore, Ala., (second-order station)—51 Cephei near upper culmination, and Polaris near lower culmination, January 29, 1869—Observer, J. G. O.—Instrument, the Würdemann transit C. S. No. 10.

Set 2.						Set 1.					
Lamp.	Micrometer. Mark.	Micrometer. 51 Cephei.	Time by sid. chronometer, Dent 2126.	Level.		Lamp.	Micrometer. Mark.	Micrometer. α Ursæ Min.	Time by sid. chronometer, Dent 2126.	Level.	
	t. d.	*t. d.*	*h. m. s.*	*E.*	*W.*		*t. d.*	*t. d.*	*h. m. s.*	*E.*	*W.*
E.	15 95					W.	15 94				
	96			54	53		94			61	58.5
	95			53	54		93			63	56
		19 42	6 53 05					18 15.0	12 55 26		
		60	53 47					18 07.4	56 02.5		
		73	54 17					17 98.0	56 45		
		84	54 47					17 89.0	57 26		
		95	55 17					17 80.0	58 02		
W.		20 34	6 56 40			E.		17 59.0	12 59 49.5		
		49	57 15					17 51.0	13 00 26.0		
		63.5	57 47					17 42.0	01 03.5		
		80	58 20.5					17 33.5	01 35.0		
		91	58 48					17 26.5	02 11.5		
	15 95						15 92.5				
	96			57	54		94			61	56.5
	96			56	55		92			59	58.5
Further observing prevented by clouds.						After this four more sets were taken.					

Determination of the value of one turn of the micrometer.

The following record is a part of a set, the whole covering more than is here needed:

δ Ursæ Minoris near lower culmination, February 5, 1869.

Chronometer time of lower culmination, 6*h*. 15*m*. 8.

Micr.	Chr. time.	Time from Cul'n.	Red'd.	Red'n time.	Time of 3 turns.		
	h. m. s.	*m.*	*s.*	*h. m. s.*	*t.*	*t.*	*m. s.*
21.0	5 55 57	19.9	+1.5	5 55 58.5	21	to 18	9 62.7
20.5	57 40	18.1	1.1	57 41.1	20.5	17.5	9 59.5
20.0	59 23.5	16.4	0.8	59 24.3	20	17	9 55.7
19.5	6 01 02.5	14.8	0.6	6 01 03.1	19.5	16.5	9 56.9
19.0	02 41.5	13.1	0.4	02 41.9	19	16	9 57.1
18.5	04 21.0	11.5	0.3	04 21.3	18.5	15.5	9 51.7
18.0	06 01.0	9.8	0.2	06 01.2	18	15	9 55.8
17.5	07 40.5	8.1	0.1	07 40.6			
17.0	09 20.0	6.5	0.0	09 20.0	Mean..........		9 57.0
16.5	11 00.0	4.8	0.0	11 00.0			
16.0	12 39.0	3.2	0.0	12 39.0			
15.5	14 13.0	1.6	0.0	14 13.0			
15.0	15 57.0	0.1	0.0	15 57.0			

The last column serves to indicate the probable uncertainty in the value. Subtracting the mean of the times and the mean of the micrometer readings from each separate measure, we obtain the following table:

t.	*m. s.*
+3.0	+10 01.6
2.5	8 19.0
2.0	6 35.8
1.5	4 57.0
1.0	3 18.2
0.5	1 38.8
0.0	−0 01.1
−0.5	−1 40.5
1.0	3 19.9
1.5	4 59.9
2.0	6 38.9
2.5	8 12.9
3.0	9 56.9

Hence, 21 turns correspond to 4179ˢ.4; 1 turn corresponds to 199ˢ.0.

Time of 1 turn=199ˢ.0	log t	2.29885
δ=86° 36′ 12″	log cos δ	8.77267
	log 15	1.17609
1 turn=176″.85		2.24761
h=26° 50′ 06″	log sec $(\varphi-p)$	0.04948
1 turn in azimuth=198″.2		2.29709

φ=30° 13′ 54″

Increase of micrometer reading corresponds to a westerly motion of the north end of the telescope.

One division of level=0″.75, B=+11.3 for 51 Cephei, and B=−20.0 for Polaris; hence, level corrections −0ˢ.28 and +1ˢ.81, respectively.

SET 2. 51 Cephei. $p = 2° 45' 32''$

	t.	d.		h.	m.	s.		″
Mean reading of mark	15	95.5	Mean of chr. times.....	6	56	00.35	Star W. of mer	824.1
Mean reading of star......	20	17.15	Correction for level....			− 0.28	Mark E. of star....	835.7
Difference	4	21.65	Chr. correction		− 1	30.48	Mark E. of mer....	11.6
	= 835″.7		Sidereal time	6	54	29.59		
			a	6	38	31.40		
			t........................		15	58.19		

SET 1. Polaris.

	t.	d.		h.	m.	s.		″
Mean reading of mark	15	92.75	Mean of chr. times.....	12	58	52.70	Star W. of mer	335.1
Mean reading of star......	17	70.14	Correction for level....			+ 1.81	Mark E. of star....	351.6
Difference	1	77.39	Chr. correction		− 1	30.48	Mark E. of mer...	16.5
	= 351″.6		Sidereal time	12	57	24.03		
			$a + 12h$	13	10	53.85		
			t........................		3	29.82		

To connect the direction of a side of the triangulation with that of the meridian, the theodolite, employed for the measure of the horizontal angle subtended between the mark and signal, must be exactly centered over the intersection of the vertical planes passing through the optical and the horizontal axes of the transit. This may be effected in several ways, to suit the peculiarities of the station-mark, the instruments, and the ground. To fix this place of intersection, the telescope may be pointed vertical by means of its finder and level, after having a cylindrical piece of cork with a pin in its axis substituted for the eye-piece; the vertical, through this pin, will thus mark the point. Four stakes may be driven into the ground a few feet from the station to admit of two silk threads being stretched across and to intersect, nearly at right angles, exactly on the point of the pin; the transit may then be removed and the theodolite mounted over the vertical of the thread intersection.

APPENDIX No. 11.

NOTE ON GULF STREAM OBSERVATIONS.

COMMUNICATED TO PROFESSOR BENJAMIN PEIRCE, SUPERINTENDENT UNITED STATES COAST SURVEY, BY ASSISTANT HENRY MITCHELL, IN CHARGE OF PHYSICAL HYDROGRAPHY.

As my connection with the Gulf Stream explorations of the past year was very brief, I am not able to report upon the work as a whole, and must therefore content myself with describing in general terms the result of those particular observations which fell to my share. My accomplished associate, L. F. Pourtales, who remained with the party during the entire season, and Acting Master Platt, commanding the steamer Bibb, have doubtless prepared detailed reports.

You will remember that in my report upon our explorations of 1867 I called your attention to my current observations at great depths below the surface, in the channel between Florida and Cuba, which seemed to show that there existed no counter-current, but that, on the contrary, the Gulf Stream in this section is essentially uniform from surface nearly down to the bottom, even where the depth is a thousand fathoms, which led me to conclude that the low temperature which we have always found in our deep casts could nowhere be attributed to the existence of a counter-current from the north. I regretted very much disturbing the popular belief in the underlying *polar current*, because its discovery would have been so satisfactory in explaining the origin of the Gulf Stream upon the heat theory, *i. e.*, as an overflow of the heated waters of the Gulf of Mexico, necessitating an inflow for the restoration of equilibrium. I therefore felt it incumbent upon me to push my observations a little further and ascertain whether, under similar conditions in other respects, the temperatures decline as you go down in a motionless sea. My first efforts of the past season were, therefore, directed to examinations in the Nicholas and Santarem Channels, which, like the Gulf of Providence and Exuma Sound, are not depressions worn by currents, but appear to be portions of the ocean-bed left undisturbed in the sudden upheaval of the Bahama Banks, or else patches of these banks that have broken and sunk down bodily.

Our examinations in the two channels named showed them to be nearly motionless masses of water, in which the decline of temperature with the depth is even a little more rapid than in the track of the Gulf Stream, as if the latter, instead of inducing its peculiar variations of temperature, had disturbed the natural order and mixed up the warm and cold waters a little. In discussing our observations as we made them it seemed to us that, in some mysterious way, depth (or pressure) and temperature were related, even more perfectly in these sheltered and stagnant basins than elsewhere. I wish you would suggest to our naval officers cruising in the Atlantic to make a few sub-current observations off Cape St. Roque, and at other points where the ocean is known to be cold at great depths. It would be curious if the horizontal motion of the water should be wholly disconnected with this subject.

I have referred to the basins of the Bahamas as offering no indications of having been excavated by running water, and I am tempted to believe that the Straits of Florida do not owe their depths to the Gulf Stream, because the narrowest part of the channel is the shallowest, and because in this neighborhood Mr. Pourtales dredged up agglomerated corals—the living and the dead combined—indicating that the stream was not wearing the bottom away, but the latter really rising.

In this last cruise we were able to anchor buoys and thus measure currents with accuracy. This can be done anywhere, and our charts ought to contain this kind of data. Our way of working was this: We first anchored a buoy, then having reeled the log-line within a free float, fastened the end of this line to the buoy, and as it reeled out, counted seconds. By this maneuver we avoided

securing the boat to the buoy, which might have caused the anchor to drag. Our way of observing sub-currents was the oldest and best, viz, by using large bodies suspended by telegraph wire.

One very calm day, while lying in the axis of the stream, we endeavored to ascertain if there was a thread of maximum velocity not far below the surface, but at 33 fathoms and 75 fathoms we could not detect the slightest variation of velocity, and as we drew up our apparatus there was no point nearer the surface which appeared to vary. Some years ago I made very delicate observations upon tidal currents in the Vineyard Sound, and failed to detect any variation of velocity till near the bottom. I had been familiar with many variations of velocity for different strata in harbor channels, especially where fresh-water feeders existed. I am satisfied that the surface current is often more tardy in small streams because of the irregular character of the banks along the water-line, the resistances being transmitted across the surface; below the vegetable earth and the roots, the path-way is smoother.

I beg you to accept this hasty little sketch in lieu of a report.

Very respectfully, yours,

H. MITCHELL.

APPENDIX No. 12.

REPORT OF ASSISTANT L. F. POURTALES ON DREDGINGS MADE IN THE SEA NEAR THE FLORIDA REEFS.

WASHINGTON, *October*, 1868.

SIR: I have the honor to submit the following report of my occupations while accompanying the hydrographical party of Acting Master R. Platt, on the coast of Florida and in the Gulf Stream.

During the first part of the season the party on board the steamer Bibb was engaged in completing the off-shore hydrography in the vicinity of the Tortugas. Whenever it was practicable the dredge was employed to get a more perfect idea of the character of the bottom, and to ascertain the distribution in depth of the various animals and plants whose remains have formed, and are now forming, all the solid land of that part of the country. When the weather did not permit sounding, the various keys and shoals were visited and examined with regard to their formation, their plants, and their animals. This small group of islands is of interest in so far as it appears to be the newest of the whole chain of Florida Keys. The soil consists mostly of loose shell-sand, consolidated only in a few places, particularly on Loggerhead Key, the largest of the group. Here it forms a coarse limestone, stratified and dipping on all sides toward the sea, being only the successive consolidated layers of the beach. It is found in all stages of formation and of destruction, and shows the recency of its formation by containing occasionally iron bolts, nuts, &c., probably not older than the time of building the light-house. The other keys are only small sand islands, generally washing away at one end and forming at the other. Several of them have entirely disappeared, for instance Southwest Key and North Key; of Bush Key little remains but a few stunted trees, (*Avicennia.*) Sand Key, used as a cemetery for the garrison of Fort Jefferson, is washing away rapidly.

The scanty vegetation appears to prove also the recent origin of the group. There appears to be not much more than a dozen indigenous plants, of which the most common is *Suriana maritima*, a large shrub or bush, improperly called bay-cedar, or simply cedar, by the inhabitants. Of trees there are none but about a dozen crippled avicennias (*vulgo* black mangrove) on Bush Key. The true mangrove, so common on the other Florida keys, does not grow on the Tortugas. The keys are separated from each other generally by deep channels with abrupt sides, running between extensive shoals. The latter are sandy and sometimes rocky, very even on top, with scattered small coral heads. The talus bordering them along the channels is generally thickly overgrown with branch coral, (*Madrepora cervicornis*,) which probably contributes in keeping up the steepness. It is rather remarkable that some of the narrow and deep channels maintain themselves without a tidal current passing through them, as, for instance, Garden Key anchorage, where the vessels at anchor never seem to be in the least influenced by a current, but always ride head to the wind, be it ever so light. Collections of animals and plants were made here. After leaving Tortugas, and while the steamer was engaged in being repaired in Key West, I made a short cruise along the Florida reef, in the schooner G. M. Bache, going as far as Carysfort light, and examining the more interesting points on the way. At Carysfort light-house may be seen one of the finest examples of a living coral reef on our coast; at least, there is a smaller proportion of dead coral than on other parts of the reef. The *Madrepora palmata* is the prevalent form. *M. cervicornis* is rather rare and small. At the Tortugas the proportion is just the reverse.

Looe Key is another interesting reef visited; the key which formerly existed there disappeared entirely in the hurricane of 1846. It was one of the few emerged points of the reef, of which the principal remaining ones are Sand Key and the Samboes. They consist in accumulations of sand, shells, and coral piled up by the sea, and always liable to be entirely destroyed by hurricanes.

On the arrival of Assistant H. Mitchell, the steamer started for the Salt Key Bank, to make soundings and current observations in the Gulf Stream, and in the St. Nicholas and Santarem

Channels. Detained by stormy weather at Salt Key and at the Double-headed Shot Keys, we had good opportunities to examine the formation of these islands, built up of the same material as the Florida Keys, but in an entirely different manner. While the Florida Keys are all flat and not higher than eight or ten feet above low-water mark, the chains of keys bordering the Salt Key Bank are elevated some fifty or sixty feet, and have generally very abrupt sides. They appear to be of various ages; Salt Key, for instance, being still sandy, while the Dog Rocks are the ruins of islands nearly worn away by the sea. As at the Bermudas and the Bahamas, the elevation of the land is not due to upheaval, but simply to successive accumulations of layers of sand by the wind, or mixed with the spray. The various stages of the process may be seen at several places, but the destructive agencies are still more prevalent. No coral reefs were seen on the Salt Key Bank, and corals in general appeared rare. The dredgings in the St. Nicholas and Santarem Channels were not very productive except in dead shells. After Mr. Mitchell left, lines of soundings were run from the Flórida Reef toward the middle of the Gulf Stream, every sounding being accompanied by a cast of the dredge. The steam reeling-apparatus on the hurricane-deck being fitted with two drums or reels, it was found practicable to perform both operations at the same time. The six following lines were run:

1st. Off Coffin's Patches, coming back from Double-headed Shot Keys, only four positions were occupied with the dredge, in 512, 195, 115, and 99 fathoms.

2d. Off Sombrero, seven positions, in 111, 121, 140, 152, 183, 262, and 517 fathoms.

3d. Off Bahia Honda, thirteen positions, 19, 35, 55, 75, 91, 105, 100, 107, 119, 128, 176, 324, and 418 fathoms.

4th. Off American Shoal, fifteen positions, in 16, 30, 43, 55, 75, 83, 98, 94, 100, 111, 120, 150, 135, 266, and 263 fathoms.

5th. Off the Eastern Samboes, nineteen positions, in 13, 34, 50, 67, 80, 93, 96, 101, 106, 106, 116, 123, 125, 125, 137, 139, 147, 298, 237 fathoms.

6th. Off Sand Key, twenty-one positions, in 23, 26, 54, 67, 82, 94, 103, 105, 119, 119, 128, 127, 123, 134, 143, 138, 154, 292, 306, 248, and 282 fathoms.

A number of casts of the dredge were also made off Sand Key, in 100 and 120 fathoms, while observing currents.

The detailed results, particularly in a zoölogical point of view, will be published by the Museum of Comparative Zoölogy, of Cambridge, as offered by Professor Agassiz. The general results were communicated to the National Academy at its late meeting in Northampton, and may be summed up here again in a few words. From the reef to a depth of about 90 fathoms, the slope is rather gradual, and the bottom consists chiefly of shell-sand of various degrees of coarseness or calcareous mud. Living organisms are scarce, the dredge bringing up only a few shells, crustacea, and worms. Between 90 and 100 fathoms, and at a distance of — miles from the reef, we find the beginning of a kind of plateau, or gentle slope, on which the bottom consists of limestone, apparently in process of formation from the consolidated debris of the shells, corals, and other animals living in considerable numbers in those depths. This rocky region forms a band parallel to the reef about — miles in breadth, and reaching to a depth of between 250 and 300 fathoms. It is inhabited by a remarkably rich fauna, in which nearly all classes of the invertebrates are represented, and, as might be expected, by a very large proportion of undescribed species. A rough enumeration will suffice in this place, as the descriptions will shortly be published elsewhere. Thus we have of molluscs about 40 species, of crustacea about —, of echinidæ — species, of asteridæ — species, holothuridæ 3, corals about 20, gorgonidæ —, hydroids —, and many of the usual deep-sea forms of foraminifera. The most characteristic and common forms are two species of brachiopods, (terebratula and waldheimia,) a cidaris and a comatula. They are brought up in almost every cast of the dredge, sometimes in great numbers. Bones of the manatee are very frequently brought up, a fact of difficult explanation, as that animal does not generally inhabit the open sea.

The inclined plateau terminates in a steeper slope, on and beyond which is found a fine white or gray mud, consisting mainly of foraminifera, which covers immense surfaces of the bottom of the ocean. The dredge showed it to be not quite destitute of higher forms of life, among which

the most interesting discovery was that of a living crinoid belonging probably to a species found only as a fossil in Guadaloupe.

Before leaving the coast of Florida, the first steps of an experiment suggested by Professor Agassiz were taken, having for its object the ascertaining of the rate of growth of corals at various depths. At first buoys with objects of a proper nature attached at different heights of the chain had been thought of. Preference was, however, given to the plan of laying a wire on the bottom from shallow to deep water, with tiles attached at short intervals, the whole to be raised after a specified time and examined. The tiles not having been furnished by the manufacturer, large shells or conches (*Strombus gigas*) were collected on the beaches and strung on the wire about 12 feet apart. One mile of such wire was laid at the Western Sambo, beginning at a depth of 4 feet and ending at 64 feet. A second wire similarly arranged was laid off the Western Dry Rocks, beginning in 9½ and ending in 25 fathoms. This second line is stronger than the former, consisting of galvanized wire obtained from the telegraph company. The positions of the ends were carefully determined by angles, so that the wires can be grappled up at any time. On the trip homeward I determined to examine a few spots off the coast of the Carolinas, marked on some charts as rocky bottom, and which I thought problematical, as our whole coast from Montauk Point to Cape Florida was believed to be purely sandy. The first spot dredged over was about latitude 33° 10′ and longitude 78° 45′, marked "rocky" and "fishing-ground," on Blunt's chart. We found only very hard sand in large ripple-marks, with a few dead shells; probably we did not find the right spot, and were not willing to spend much time on it. But nearer shore, fourteen miles north-northeast of Bald Head, North Carolina, nine fathoms, and in seven fathoms, close to the entrance of Cape Fear River, patches of rocky bottom were found, with an abundant growth of coral, (*Occulina arbuscula*,) shells, &c. Specimens of the rock itself were obtained in small fragments of limestone, scarcely sufficient to decide if it is of recent formation or the continuation of the tertiary strata found at a short distance inland.

Respectfully submitted.

L. F. POURTALES,
Assistant United States Coast Survey.

Professor BENJAMIN PEIRCE,
Superintendent United States Coast Survey.

APPENDIX No. 13.

LIST OF GEOGRAPHICAL POSITIONS DETERMINED BY THE UNITED STATES COAST SURVEY, CONTINUED FROM THE ANNUAL REPORTS OF 1851, 1853, 1855, 1857, 1859, 1864, AND 1865.

Full explanations having been given in the reports above referred to, it suffices here to state that no general changes have been made in the fundamental latitudes and longitudes from those given in preceding reports; in Section VII the longitude of the flag-staff in the public square of Pensacola has been taken 87° 12′ 43″.57; in Section VIII, the longitudes of positions east of Atchafalaya Bay depend as heretofore on the longitude of Fort Morgan.

GEOGRAPHICAL POSITIONS.

Section I.—St. Croix River, Me.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
NAVY	45 03 16.70	67 02 17.82						
SHORTLAND	45 05 25.50	67 08 50.19	294 49 08	Navy	114 53 46	9457.8	10342.7	5.88
Chamcook 2	45 07 29.14	67 04 38.99	338 22 33	Navy	158 24 13	8381.0	9165.2	5.21
			55 13 26	Shortland	235 10 29	6686.6	7312.2	4.15
Devil's Head	45 09 11.96	67 09 21.63	297 10 32	Chamcook 2	117 13 53	6942.4	7592.0	4.31
			354 22 59	Shortland	174 23 21	7023.6	7680.8	4.36
Table Top	45 09 55.87	67 07 23.84	321 29 54	Chamcook 2	141 31 51	5786.1	6327.5	3.60
			62 13 41	Devil's Head	242 12 17	2907.7	3179.7	1.81
Cookson's Island	45 13 06.21	67 10 34.74	323 13 21	Chamcook 2	143 17 33	12984.1	14189.0	8.07
			324 38 16	Table Top	144 40 31	7203.0	7877.0	4.48
Lane	45 09 31.33	67 12 40.71	277 48 38	Devil's Head	97 51 00	4388.8	4799.4	2.73
			202 30 15	Cookson's Island	22 31 44	7180.1	7851.9	4.46
Sinclair	45 10 57.39	67 13 40.66	333 45 43	Lane	153 46 25	2961.3	3238.4	1.84
			225 33 28	Cookson's Island	45 35 40	5681.0	6212.6	3.53
Todd	45 10 18.80	67 18 30.98	280 48 33	Lane	100 52 42	7787.6	8516.3	4.84
			243 31 01	Cookson's Island	63 36 39	11607.6	12693.7	7.21
Curtis	45 13 35.37	67 17 38.45	10 42 23	Todd	190 41 46	6175.1	6752.9	3.84
			275 31 12	Cookson's Island	95 36 13	9286.6	10155.5	5.77
Rye	45 07 23.47	67 25 09.21	269 30 23	Chamcook	89 44 55	26883.9	29399.5	16.71
			12 16 15	Cooper	192 14 28	15513.7	16965.3	9.64
St. David	45 15 01.70	67 13 39.74	319 44 59	Chamcook	139 51 22	18288.9	20000.2	11.36
			32 08 49	Cooper	211 58 54	34579.5	37815.1	21.49
Calais, astronomical observatory.	45 11 04.59	67 16 30.17	206 54 48	St. David	26 56 49	8209.5	8977.7	5.10
			293 06 28	Chamcook	113 14 52	16896.7	18477.7	10.50
Meridian	45 12 39.08	67 16 30.22	319 08 06	Lane	139 10 49	7660.5	8377.2	4.76
			310 17 23	Sinclair	130 19 23	4852.5	5306.5	3.01
Eye	45 07 21.00	67 09 24.24	348 12 19	Shortland	168 12 43	3641.8	3982.6	2.26
			180 57.11	Devil's Head	0 57 13	3425.5	3746.0	2.13
Plaster Mill, chimney	45 07 23.48	67 08 32.33	197 38 13	Table Top	17 39 02	4936.1	5398.0	3.07
			268 00 51	Chamcook 2	88 03 36	5101.7	5579.1	3.17
Chamcook Church	45 08 02.24	67 06 16.91	34 42 57	Shortland	214 41 08	5884.7	6435.3	3.66
			118 05 19	Devil's Head	298 03 08	4573.2	5001.1	2.84
Bayside school-house	45 08 54.80	67 07 19.35	307 01 40	Chamcook 2	127 03 34	4389.1	4799.8	2.73
			101 13 41	Devil's Head	281 12 15	2722.5	2977.2	1.69
De Monts Island	45 07 43.08	67 07 40.29	141 06 22	Devil's Head	321 05 10	3525.1	3855.0	2.19
			19 47 36	Shortland	199 46 47	4513.2	4935.5	2.80
Plaster Point, flag	45 10 29.20	67 09 22.41	359 35 22	Devil's Head	179 35 23	2387.4	2610.8	1.48
			161 57 17	Cookson's Island	341 56 26	5094.2	5570.9	3.17
Chick's house, chimney	45 09 23.41	67 10 27.29	124 30 36	Sinclair	304 28 19	5122.7	5602.1	3.18
			255 56 24	Table Top	75 58 34	4129.6	4516.0	2.57
Raven's Head, flag	45 10 04.39	67 10 17.99	176 16 28	Cookson's Island	356 16 16	5624.2	6150.5	3.49
			71 52 57	Lane	251 51 16	3279.5	3586.4	2.04

GEOGRAPHICAL POSITIONS—Continued.

Section I.—St. Croix River, Me.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Banforth's house, chimney at east end.	45 13 42.44	67 12 51.53	290 31 58	Cookson's Island	110 33 35	3186.5	3484.7	1.98
			331 13 31	Devil's Head	151 16 00	7523.6	8227.5	4.67
Smart's Mountain, flag	45 12 02.34	67 08 55.46	46 33 15	Lane	226 30 35	6775.7	7409.7	4.21
			132 18 47	Cookson's Island	312 17 37	2929.0	3203.0	1.82
Whidden's derrick	45 09 53.57	67 11 41.22	127 04 35	Sinclair	307 03 10	3268.1	3573.9	2.03
			269 15 09	Table Top	89 18 12	5620.7	6146.7	3.49
Breakwater, flag	45 10 08.03	67 12 04.90	126 05 33	Sinclair	306 04 25	2586.9	2828.9	1.61
			273 28 19	Table Top	93 31 38	6148.7	6724.0	3.82
Calais, Baptist church	45 11 15.63	67 16 18.26	304 06 36	Lane	124 09 10	5737.9	6274.8	3.56
			157 55 43	Curtis	337 54 46	4654.6	5090.1	2.89
New Brunswick, St. Stephen's Church (English church.)	45 11 37.21	67 15 58.06	54 04 18	Todd	234 02 30	4123.3	4509.1	2.56
			292 16 19	Sinclair	112 17 56	3241.2	3544.5	2.01
Birch, Two-hundred-foot Hill	45 09 22.57	67 14 07.93	191 29 49	Sinclair	11 30 08	2986.8	3266.2	1.86
			261 54 28	Lane	81 55 30	1923.9	2104.0	1.20
Frenchman's Bay, Me.								
MOUNT DESERT	44 21 03.86	68 13 15.48						
TUCKER	44 31 08.01	68 10 39.90	10 28 09	Mount Desert	190 26 20	18960.8	20735.0	11.78
Hadley's Point	44 26 18.29	68 18 43.86	230 03 09	Tucker	50 08 48	13939.8	15244.1	8.66
			323 08 31	Mount Desert	143 12 21	12123.4	13257.8	7.53
Trenton Point	44 27 59.15	68 17 57.84	238 53 21	Tucker	58 58 28	11295.0	12351.9	7.02
			333 59 20	Mount Desert	154 02 38	14258.4	15592.6	8.86
Springer	44 32 02.02	68 17 19.09	280 40 14	Tucker	100 44 54	8969.9	9809.2	5.57
			6 31 05	Trenton Point	186 30 38	7544.5	8250.4	4.69
Crabtree	44 28 00.96	68 13 22.59	89 30 01	Trenton Point	269 26 49	6083.8	6653.1	3.78
			211 53 19	Tucker	31 55 13	6800.3	7436.6	4.23
Commons	44 29 04.83	68 16 19.32	47 03 06	Trenton Point	227 01 57	2974.7	3253.0	1.85
			243 04 38	Tucker	63 08 36	8405.9	9192.5	5.22
Bragdon	44 36 17.25	68 15 38.43	325 21 35	Tucker	145 25 05	11596.9	12682.0	7.21
			3 52 23	Commons	183 51 54	13376.9	14628.5	8.31
McFarland	44 32 12.21	68 21 06.78	223 44 02	Bragdon	43 47 53	10472.5	11452.4	6.51
			278 05 11	Tucker	98 12 30	13981.5	15289.7	8.69
Higgins	44 23 19.08	68 21 47.09	210 22 21	Trenton Point	30 25 01	10021.1	10958.8	6.23
			216 13 05	Hadley's Point	36 15 13	6857.2	7498.9	4.26
Sands Point	44 26 14.67	68 15 38.72	222 31 07	Crabtree	42 32 42	4451.8	4868.4	2.77
			136 22 10	Trenton Point	316 20 33	4456.2	4873.2	2.77
Bunker	44 27 28.11	68 19 42.56	328 55 58	Hadley's Point	148 56 39	2515.4	2750.8	1.56
			292 46 47	Sands Point	112 49 38	5848.1	6395.3	3.63
Richards	44 26 22.96	68 18 34.60	195 18 23	Trenton Point	15 18 49	3078.0	3366.0	1.91
			273 44 54	Sands Point	93 46 57	3897.6	4262.3	2.42
Goose Cove	44 26 05.24	68 22 13.32	265 00 32	Hadley's Point	85 02 59	4649.0	5084.0	2.89
			232 29 03	Bunker	52 30 48	4201.1	4594.2	2.61
Flag-staff on McFarland's Hill	44 32 06.48	68 21 06.76	223 04 16	Bragdon	43 08 07	10600.9	11592.8	6.59
			179 57 29	McFarland	359 57 29	176.8	193.3	0.11
School-house at Trenton Point, cupola.	44 27 34.79	68 18 02.08	21 22 06	Hadley's Point	201 21 37	2535.2	2772.4	1.58
			17 58 13	Richards	197 57 50	2330.6	2548.7	1.45
Dead tree on Thomas Island	44 26 06.97	68 20 13.67	260 00 45	Hadley's Point	80 01 48	2016.4	2205.1	1.25
			88 51 42	Goose Cove	268 50 18	2646.1	2893.7	1.64
West Trenton, Union Church	44 26 13.03	68 23 41.26	14 55 14	Bartlett	194 53 57	9516.5	10406.9	5.91
			268 33 21	Hadley's Point	88 36 49	6578.1	7193.6	4.09
East Trenton, tall white spire	44 28 42.32	68 20 17.10	335 07 02	Hadley's Point	155 08 07	4899.9	5358.4	3.04
			11 17 25	Higgins	191 16 22	10172.9	11124.8	6.32
Baptist church at Trenton Point, southwest spire.	44 28 01.47	68 18 53.88	356 01 08	Hadley's Point	176 01 15	3192.1	3490.8	1.98
			352 00 57	Richards	172 01 11	3070.0	3357.3	1.91
W. Desiles' house, chimney	44 27 11.84	68 16 44.87	251 14 43	Crabtree	71 17 05	4721.3	5163.0	2.93
			58 07 54	Richards	238 06 37	2856.6	3123.9	1.77
House on Alley Island, north-east chimney.	44 24 23.65	68 22 57.03	87 51 36	Oak Point	267 50 23	2324.5	2542.0	1.44
			322 09 37	Higgins	142 10 26	2523.0	2759.1	1.57
Poplar tree	44 25 44.33	68 23 29.09	248 55 17	Goose Cove	68 56 10	1795.8	1963.8	1.12
			18 07 20	Bartlett	198 05 54	8743.6	9561.7	5.43

GEOGRAPHICAL POSITIONS—Continued.

Section I.—Frenchman's Bay, Me.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
W. F. Mosely's house, chimney.	44 29 37.98	68 16 28.73	185 08 33	Bragdon	5 09 08	12373.2	13531.0	7.69
			165 57 45	Springer	345 57 10	4582.6	5011.3	2.85
Chimney of one-story white house.	44 29 33.74	68 18 11.73	141 41 45	McFarland	321 39 42	6234.2	6817.5	3.87
			194 15 03	Springer	14 15 40	4721.8	5163.6	2.93
H. Merchant's barn, north gable	44 31 25.98	68 19 04.58	117 53 06	McFarland	297 51 40	3052.2	3337.8	1.90
			244 27 44	Springer	64 28 58	2581.1	2822.6	1.60
Crabtree's Neck, chimney of Baptist church.	44 29 55.91	68 15 00.74	47 45 38	Commons	227 44 43	2345.0	2564.4	1.46
			117 31 47	McFarland	297 27 30	9112.1	9964.7	5.66
Wooster's house, south chimney.	44 29 00.11	68 14 19.78	18 52 29	Sands Point	198 51 34	5396.0	5900.9	3.35
			68 40 41	Trenton Point	248 39 08	5173.1	5657.2	3.21
D. Hodgkins' house, east chimney.	44 28 32.04	68 15 56.97	69 12 18	Trenton Point	249 10 53	2857.5	3124.9	1.78
			354 33 52	Sands Point	174 34 05	4258.8	4657.3	2.65
S. N. McFarland's house, chimney.	44 28 08.66	68 13 29.01	114 44 48	Commons	294 42 49	4143.6	4531.3	2.57
			87 11 54	Trenton Point	267 08 46	5948.5	6505.1	3.70
Blue Hill and Union River Bays, Me.								
SWAN'S ISLAND	44 09 43.97	68 25 00.12						
NASKEAG POINT	44 14 04.93	68 31 39.04	312 14 32	Swan's Island	132 19 10	11971.7	13091.9	7.44
Seal Cove	44 17 15.26	68 24 19.82	58 57 16	Naskeag Point	238 52 10	11375.2	12439.6	7.07
			3 40 34	Swan's Island	183 40 06	13956.5	15262.4	8.67
Bass Harbor	44 13 26.88	68 19 45.86	139 15 36	Seal Cove	319 12 25	9306.5	10177.3	5.78
			45 26 16	Swan's Island	225 22 37	9798.7	10715.5	6.09
Great Duck Island	44 09 21.24	68 14 35 18	137 43 35	Bass Harbor	317 39 58	10250.0	11209.1	6.37
			92 57 10	Swan's Island	272 49 54	13902.0	15202.8	8.64
Bar Island	44 15 19.35	68 27 07.83	344 40 12	Swan's Island	164 41 41	10731.5	11735.6	6.67
			289 27 01	Bass Harbor	109 32 09	10401.9	11375.2	6.46
Hopkins	44 19 20.58	68 28 54.57	20 32 28	Naskeag Point	200 30 33	10401.5	11374.7	6.46
			302 23 47	Seal Cove	122 26 59	7213.6	7888.5	4.48
Bartlett	44 21 15.07	68 25 31.95	347 48 28	Seal Cove	167 49 18	7573.2	8281.8	4.71
			51 47 23	Hopkins	231 45 01	5712.5	6247.0	3.55
Carter	44 21 03.37	68 30 19.88	7 44 33	Naskeag Point	187 43 38	13031.7	14251.1	8.10
			266 43 56	Bartlett	86 47 17	6386.4	6984.0	3.97
Morgan	44 25 19.09	68 29 33.39	7 26 00	Carter	187 25 27	7959.1	8703.9	4.95
			324 37 19	Bartlett	144 40 08	9234.3	10098.3	5.74
Oak Point	44 24 20.85	68 24 42.04	105 36 59	Morgan	285 33 35	6691.4	7317.5	4.16
			10 54 29	Bartlett	190 53 54	5839.3	6385.7	3.63
Haynes	44 24 48.93	68 25 37.50	100 08 28	Morgan	280 05 43	5300.5	5796.4	3.29
			358 55 52	Bartlett	178 55 56	6601.9	7219.7	4.10
Smith	44 27 28.29	68 27 45.12	30 59 28	Morgan	210 58 12	4650.8	5086.0	2.89
			330 08 22	Haynes	150 09 52	5670.7	6201.3	3.52
Bluff Point	44 27 53.93	68 25 22.50	75 55 11	Smith	255 53 31	3250.4	3554.5	2.02
			3 19 31	Haynes	183 19 21	5719.6	6254.8	3.55
Cunningham	44 21 27.65	68 36 31.76	232 18 26	Morgan	52 23 19	11694.8	12789.0	7.27
			275 09 37	Carter	95 13 57	8269.5	9043.3	5.14
Wood	44 24 15.79	68 32 04.02	48 49 16	Cunningham	228 46 09	7877.2	8614.3	4.89
			338 46 24	Carter	158 47 37	6370.4	6966.4	3.96
Herriman's Point	44 17 59.78	68 31 40.67	277 57 37	Seal Cove	98 02 45	9867.4	10790.7	6.13
			235 51 58	Hopkins	55 53 54	4445.2	4861.1	2.76
Chimney of Welsh's house on Gott's Island.	44 11 58.26	68 19 35.58	305 57 45	Great Duck Island	126 01 14	8245.9	9017.5	5.12
			175 13 38	Bass Harbor	355 13 31	2744.4	3001.2	1.71
Dead tree on western point of Bass Harbor.	44 13 40.57	68 21 30.41	32 32 45	Swan's Island	212 30 19	8660.3	9470.6	5.38
			112 11 25	Bar Island	292 07 30	8083.0	8839.3	5.02
Captain Lopan's house, chimney.	44 15 38.77	68 22 49.80	314 54 38	Bass Harbor	134 56 46	5763.9	6303.3	3.58
			84 02 35	Bar Island	263 59 35	5754.4	6292.8	3.57
Hardwood Island.	44 17 57.23	68 26 41.06	292 27 40	Seal Cove	112 29 19	3388.0	3705.0	2.10
			131 01 18	Hopkins	310 59 45	3920.6	4287.5	2.44
Old Congregationalist church, (Mount Desert.)	44 20 05.75	68 23 41.89	9 04 55	Seal Cove	189 04 29	5328.3	5826.9	3.31
			101 27 11	Carter	281 22 33	8993.6	9835.1	5.59

GEOGRAPHICAL POSITIONS—Continued.

Section I.—Blue Hill and Union River Bays, Me.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
House on Tinker's Island, north chimney.	44 16 29.61	68 28 44.65	165 58 53	Carter	345 57 47	8710.1	9525.1	5.41
			256 28 49	Seal Cove	76 31 54	6038.1	6603.1	3.75
House on Tinker's Island, east chimney.	44 15 59.26	68 28 04.06	169 47 23	Hopkins	349 46 48	6313.2	6903.9	3.92
			53 31 37	Naskeag Point	233 29 07	5932.2	6487.3	3.69
Barn on Ship Island, northeast gable.	44 14 05.49	68 26 07.20	89 54 09	Naskeag Point	269 50 18	7363.3	8052.3	4.58
			202 06 57	Seal Cove	22 08 12	6322.5	6914.1	3.93
Flag-staff on Fly's Point	44 16 05.24	68 31 37.41	283 18 07	Bar Island	103 21 15	6144.6	6719.5	3.82
			210 53 36	Hopkins	30 55 30	7026.5	7684.0	4.37
Chimney of white house with red end.	44 19 30.96	68 33 52.63	313 53 19	Herriman's Point	133 54 51	4058.5	4438.3	2.52
			272 44 57	Hopkins	92 48 25	6611.5	7230.1	4.11
S. Candage's house, south chimney.	44 21 25.71	68 32 37.72	282 43 37	Carter	102 45 13	3129.3	3422.1	1.94
			158 52 16	Blue Hill	338 50 32	9125.5	9979.4	5.67
North chimney of white house at Blue Hill Falls.	44 22 12.93	68 33 08.89	299 49 45	Carter	119 51 43	4314.3	4718.0	2.68
			200 43 45	Wood	20 44 30	4054.4	4433.8	2.52
G. J. Wood's house, west chimney.	44 24 12.29	68 32 01.29	338 56 03	Carter	158 57 14	6248.2	6832.9	3.88
			129 27 43	Blue Hill	309 25 33	5303.9	5800.2	3.30
West chimney of red house on Oak Point.	44 23 57.69	68 25 13.53	4 38 36	Bartlett	184 38 23	5035.8	5507.0	3.13
			113 38 01	Morgan	293 34 59	6274.0	6861.1	3.90
East chimney of house on Newbury Neck.	44 22 54.72	68 27 40.53	13 56 11	Hopkins	193 55 19	6809.8	7447.0	4.23
			217 39 25	Haynes	37 40 51	4454.1	4870.9	2.77
Union Church on Newbury Neck	44 24 27.68	68 27 25.31	119 16 01	Morgan	299 14 31	3247.4	3551.3	2.02
			203 05 33	Bluff Point	23 06 59	6921.0	7568.6	4.30
South chimney of white house on Newbury Neck.	44 26 47.12	68 27 31.84	325 15 25	Haynes	145 16 45	4438.4	4853.7	2.76
			234 10 59	Bluff Point	54 12 30	3525.4	3855.3	2.19
Chimney of Methodist church, Surry.	44 27 28.68	68 27 51.44	328 59 32	Haynes	149 01 06	5751.6	6289.7	3.57
			256 39 39	Bluff Point	76 41 23	3383.1	3699.7	2.10
East chimney of white house, Patten's Bay.	44 29 31.59	68 27 14.60	10 03 21	Smith	190 03 00	3864.8	4226.4	2.40
			320 34 25	Bluff Point	140 35 44	3901.3	4266.3	2.42
Marked tree on Weymouth Point.	44 28 58.08	68 25 55.04	41 17 24	Smith	221 16 07	3687.7	4032.7	2.29
			340 02 02	Bluff Point	160 02 25	2106.4	2303.5	1.31
White house, chimney	44 29 39.85	68 24 51.04	43 28 12	Smith	223 26 10	5593.4	6116.7	3.48
			12 00 25	Bluff Point	192 00 03	3342.0	3654.7	2.08
Fish-house, north gable	44 23 02.38	68 30 00.49	299 05 49	Bartlett	119 08 57	6805.9	7442.8	4.23
			129 15 34	Blue Hill	309 12 00	8739.4	9557.2	5.43
Congregationalist church spire at Blue Hill.	44 24 40.03	68 35 09.65	280 18 17	Wood	100 20 27	4173.5	4564.0	2.59
			316 10 06	Carter	136 13 29	9264.8	10131.6	5.76
Isle au Haut Bay, Me.								
ISLE AU HAUT	44 04 01.90	68 36 42.51	....	....	....	....	....	....
FOX ROCKS	44 06 26.90	68 52 21.53	282 00 03	Isle au Haut	102 10 56	21361.7	23360.5	13.27
BURNT COVE	44 09 18.59	68 40 50.78	71 01 36	Fox Rocks	250 53 35	16242.3	17762.1	10.09
			330 31 00	Isle au Haut	150 33 53	11224.8	12275.1	6.97
COOMBS HILL	44 05 17.38	68 46 51.64	279 41 35	Isle au Haut	99 48 39	13750.5	15037.1	8.54
			227 06 19	Burnt Cove	47 10 31	10944.1	11968.2	6.80
Leadbetter's Island	44 04 45.19	68 54 00.08	59 23 01	High Island	239 16 35	14367.1	15711.5	8.93
			214 54 43	Fox Rocks	34 55 51	3828.5	4186.7	2.38
Sands	44 02 52.59	68 50 11.32	70 04 25	Hurricane Island	250 02 24	4141.5	4529.0	2.57
			124 20 15	Leadbetters Island	304 17 36	6163.3	6740.0	3.83
Isle au Haut Mount	44 03 45.39	68 50 08.21	236 59 31	Coombs Hill	57 01 48	5214.0	5701.9	3.24
			52 29 44	Hurricane Island	232 27 40	4994.9	5462.3	3.10
Hay Island	44 00 54.69	68 47 16.71	183 55 59	Coombs Hill	3 56 16	8126.0	8886.4	5.05
			105 59 42	Hurricane Island	285 55 39	8094.0	8851.4	5.03
Starboard Rock	44 05 38.48	68 49 01.91	282 39 11	Coombs Hill	102 40 42	2969.8	3247.7	1.85
			22 55 05	Isle au Haut Mount	202 54 19	3789.0	4143.5	2.35
White Island	44 02 36.89	68 54 20.00	299 26 58	Hurricane Island	119 27 49	1886.9	2063.4	1.17
			186 23 05	Leadbetters Island	6 23 19	3984.0	4356.8	2.47
Barley Hill, flag	44 04 07.85	68 46 36.78	171 14 13	Coombs Hill	351 14 03	2171.1	2374.2	1.35
			8 29 00	Hay Island	188 28 32	6026.9	6590.8	3.74
Sheep Island, flag	44 02 19.33	68 47 08.49	183 53 55	Coombs Hill	3 54 07	5507.6	6022.9	3.42
			4 00 22	Hay Island	184 00 16	2618.4	2863.4	1.63

GEOGRAPHICAL POSITIONS—Continued.

Section I.—Isle au Haut Bay, Me.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Carver's Harbor, church-spire	44 02 53.49	68 49 29.43	151 40 39	Isle au Haut Mount	331 40 12	1819.3	1989.6	1.13
			321 07 12	Hay Island	141 08 44	4708.9	5149.5	2.93
Basin	44 04 29.65	68 52 20.58	102 14 31	Leadbetter's Island	282 13 22	2264.9	2476.9	1.41
			316 08 50	Sands	136 10 20	4152.9	4541.5	2.58
Captain Lane's house, south chimney.	44 02 18.52	68 49 45.66	151 29 14	Sands	331 28 56	1196.7	1308.6	0.74
			128 39 48	Leadbetter's Island	308 36 51	7248.5	7926.7	4.50
Dogy Point	44 03 13.49	68 51 59.90	136 38 03	Leadbetter's Island	316 36 39	3893.5	4257.8	2.42
			284 56 07	Sands	104 57 23	2501.2	2735.2	1.55
Spruce Island	44 08 14.91	68 36 00.12	69 20 43	Coombs Hill	249 13 09	15847.7	17330.5	9.85
			6 53 17	Isle au Haut	186 52 47	7864.9	8600.9	4.89
Duck Harbor Mount	44 01 22.07	68 38 37.19	123 28 06	Coombs Hill	303 22 22	13184.6	14418.3	8.19
			207 21 05	Isle au Haut	27 22 25	5554.1	6073.8	3.45
Great Spoon Island	44 02 35.47	68 33 11.30	160 17 48	Spruce Island	340 15 51	11128.4	12169.7	6.91
			72 41 39	Duck Harbor Mount	252 37 52	7601.2	8312.4	4.72
Kimball's Island	44 04 23.21	68 39 44.82	344 55 47	Duck Harbor Mount	164 56 34	5788.9	6330.5	3.60
			170 52 15	Burnt Cove	350 51 29	9233.0	10096.9	5.74
Trial Point, flag	44 03 24.77	68 38 37.86	359 47 15	Duck Harbor Mount	179 47 15	3787.1	4141.5	2.35
			164 52 20	Burnt Cove	344 50 48	11312.6	12371.1	7.03
West Ear Island, flag	44 00 12.97	68 38 59.20	203 17 23	Isle au Haut	23 18 58	7692.4	8412.2	4.78
			192 56 58	Duck Harbor Mount	12 57 13	2188.2	2393.0	1.36
East Head, flag	44 00 50.63	68 36 36.00	234 36 45	Great Spoon Island	54 39 07	5589.2	6112.2	3.47
			109 47 36	Duck Harbor Mount	289 46 12	2868.3	3136.7	1.78
Isle au Haut, church-spire	44 04 24.50	68 37 42.63	155 16 21	Burnt Cove	335 14 10	9993.9	10929.1	6.21
			197 45 50	Spruce Island	17 47 01	7467.4	8166.1	4.64
Merchant's Island, flag	44 06 11.19	68 38 24.79	330 17 53	Isle au Haut	150 19 04	4593.3	5023.1	2.85
			150 43 10	Burnt Cove	330 41 28	6631.6	7252.1	4.12
Thurlow's Island, flag	44 08 23.14	68 39 51.62	332 26 04	Isle au Haut	152 28 16	9093.1	9943.9	5.65
			142 28 05	Burnt Cove	322 27 24	2157.9	2359.8	1.34
Russ Island	44 09 02.45	68 38 17.48	98 20 22	Burnt Cove	278 18 35	3442.8	3765.0	2.14
			295 39 32	Spruce Island	115 41 08	3387.0	3704.0	2.10
St. Helena Island	44 07 56.96	68 38 24.09	342 41 35	Isle au Haut	162 42 46	7597.7	8308.6	4.72
			260 10 04	Spruce Island	80 11 44	3247.7	3551.6	2.02
McGlanthry's Island, flag	44 07 19.08	68 36 41.71	208 13 03	Spruce Island	28 13 32	1955.1	2138.1	1.22
			0 10 08	Isle au Haut	180 10 07	6085.3	6654.7	3.78
Mark Island, flag	44 07 12.21	68 33 59.39	31 42 58	Isle au Haut	211 41 04	6903.5	7549.4	4.29
			352 51 27	Great Spoon Island	172 52 00	8607.5	9412.9	5.35
Fog Island, flag	44 06 01.38	68 34 14.07	150 14 23	Spruce Island	330 13 09	4747.9	5192.1	2.95
			347 36 00	Great Spoon Island	167 36 44	6506.6	7115.4	4.04
York Island	44 04 10.73	68 34 52.60	168 44 21	Spruce Island	348 43 34	7683.9	8402.9	4.77
			322 30 35	Great Spoon Island	142 31 45	3704.8	4051.4	2.30
Penobscot River, Me.								
COBB'S HILL	44 38 52.47	68 48 15.78						
TREVETT	44 39 03.30	68 50 51.38	275 33 35	Cobb's Hill	95 35 24	3444.7	3767.0	2.14
Stubb's Hill	44 40 46.02	68 47 32.56	15 11 55	Cobb's Hill	195 11 25	3631.8	3971.7	2.26
			54 07 08	Trevett	234 04 48	5406.3	5912.2	3.36
Baker	44 41 23.48	68 50 16.21	330 20 38	Cobb's Hill	150 22 03	5362.9	5864.7	3.33
			287 46 23	Stubb's Hill	107 48 18	3784.3	4138.4	2.35
Bald Hill	44 41 45.88	68 49 25.52	343 58 40	Cobb's Hill	163 59 29	5568.3	6089.3	3.46
			58 14 07	Baker	238 13 31	1312.7	1435.6	0.82
Hampden	44 43 25.43	68 50 15.24	0 19 31	Baker	180 19 30	3764.0	4116.2	2.34
			323 56 10	Stubb's Hill	143 58 05	6085.3	6654.7	3.78
Orrington	44 43 37.74	68 48 33.52	80 22 17	Hampden	260 21 05	2270.3	2482.7	1.41
			28 37 05	Baker	208 35 52	4720.3	5161.9	2.93
Academy	44 44 22.86	68 49 50.83	16 51 31	Hampden	196 51 14	1852.1	2025.4	1.15
			309 17 57	Orrington	129 18 52	2198.1	2403.8	1.37
Nichols	44 44 48.91	68 48 11.54	69 46 36	Academy	249 45 26	2327.7	2545.5	1.45
			12 24 46	Orrington	192 24 31	2250.0	2460.5	1.40
Stewart	44 45 54.22	68 48 15.86	36 32 08	Academy	216 31 01	3509.1	3837.5	2.18
			357 17 50	Nichols	177 17 53	2017.1	2205.9	1.25

GEOGRAPHICAL POSITIONS—Continued.

Section I.—Penobscot River, Me.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Doane	44 45 14.80	68 47 02.38	126 59 04	Stewart	306 58 12	2022.7	2212.0	1.26
			62 19 03	Nichols	242 18 14	1717.8	1878.5	1.07
Horseback	44 46 02.69	68 47 15.17	78 55 02	Stewart	258 54 19	1360.0	1487.2	0.85
			349 13 48	Doane	169 13 57	1504.7	1645.4	0.94
High Head	44 47 08.03	68 46 17.64	48 46 32	Stewart	228 45 09	3456.2	3779.6	2.15
			15 43 28	Doane	195 42 57	3630.7	3970.5	2.26
Chamberlin	44 48 00.65	68 45 07.05	46 47 01	Stewart	226 44 48	5696.8	6229.8	3.54
			26 21 38	Doane	206 20 17	5712.4	6246.9	3.55
Hinks	44 46 35.00	68 45 25.45	188 41 47	Chamberlin	8 42 00	2674.2	2924.4	1.66
			71 26 44	Stewart	251 24 44	3952.5	4322.3	2.46
Fort Knox	44 33 55.75	68 47 48.26	325 18 41	McClouds	145 19 20	2137.6	2337.6	1.33
			216 07 13	Bucksport	36 07 48	1871.2	2046.3	1.16
Parker's Point	44 38 56.60	68 49 25.11	274 45 48	Cobb's Hill	94 46 37	1532.8	1676.3	0.95
			216 16 04	Stubb's Hill	36 17 23	4189.5	4581.5	2.60
John Bolian's house, chimney	44 39 44.41	68 49 21.02	57 29 50	Trevett	237 28 47	2360.6	2581.5	1.47
			318 07 10	Cobb's Hill	138 07 56	2153.4	2354.9	1.34
Oak Point	44 40 11.06	68 48 37.74	54 37 29	Trevett	234 35 55	3610.9	3948.8	2.24
			348 42 54	Cobb's Hill	168 43 09	2473.6	2705.0	1.54
Herr's Hill	44 40 43.20	68 49 48.69	173 20 40	Hampden	353 20 21	5041.3	5513.0	3.13
			154 00 56	Baker	334 00 37	1383.2	1512.6	0.86
Bragdon's Castle	44 43 15.14	68 49 48.00	117 55 42	Hampden	297 55 23	678.3	741.8	0.42
			246 55 58	Orrington	66 56 51	1781.3	1948.0	1.11
East Bluff, white flag in tree	44 42 44.68	68 49 48.70	13 35 15	Baker	193 34 55	2578.8	2820.1	1.60
			225 16 45	Orrington	45 17 38	2327.9	2545.7	1.45
Sandy Head	44 41 52.39	68 50 01.34	210 43 09	Orrington	30 44 11	3783.0	4137.0	2.35
			173 55 24	Hampden	353 55 14	2888.0	3158.2	1.79
Hampden, dome of belfry with clock-face.	44 43 56.36	68 50 18.78	283 55 33	Orrington	103 56 47	2386.2	2609.5	1.48
			239 53 07	Nichols	59 54 36	3235.5	3538.2	2.01
Hampden, Congregationalist church.	44 44 46.98	68 49 50.62	321 33 13	Orrington	141 34 08	2728.4	2983.7	1.70
			268 23 39	Nichols	88 24 49	2180.0	2384.0	1.35
Crosby's Narrows, flag in tree	44 45 06.09	68 48 44.37	263 09 29	Doane	83 10 41	2259.2	2470.6	1.40
			228 18 26	Horseback	48 19 29	2626.6	2872.4	1.63
Mayhew's steam saw-mill, chimney.	44 45 33.52	68 47 43.18	214 22 35	Horseback	34 22 55	1091.0	1193.1	0.68
			131 38 30	Stewart	311 38 07	961.5	1051.4	0.60
Edmonds' steam saw-mill, chimney.	44 46 28.12	68 46 56.32	263 55 13	Hinks	83 56 17	2008.9	2196.8	1.25
			220 03 17	Chamberlin	40 04 34	3731.8	4081.0	2.32
South Brewer	44 46 18.93	68 46 19.33	67 48 14	Horseback	247 47 35	1326.1	1450.2	0.82
			25 34 04	Doane	205 33 34	2194.1	2399.4	1.36
Brewer belfry	44 47 44.58	68 45 35.53	354 06 35	Hinks	174 06 42	2159.0	2361.0	1.34
			231 36 37	Chamberlin	51 36 57	798.4	873.1	0.50
Brewer flag-staff	44 47 29.94	68 45 13.52	53 37 31	Stewart	233 35 22	4979.8	5445.7	3.09
			8 47 40	Hinks	188 47 31	1715.9	1876.5	1.07
Bangor, Unitarian church spire	44 47 54.95	68 46 03.98	341 03 07	Hinks	161 03 34	2608.9	2853.0	1.62
			261 59 37	Chamberlin	82 00 17	1263.4	1381.6	0.79
Cupola of house on Thomas Hill	44 48 23.90	68 46 38.12	334 34 44	Hinks	154 35 35	3721.3	4069.5	2.31
			289 43 21	Chamberlin	109 44 25	2125.8	2324.7	1.32
Muscongus Bay, Me.								
DAVIS	43 54 31.33	69 22 40.31	....	....	....	....	....	.....
MUSCONGUS	43 58 41.63	69 26 23.46	327 11 32	Davis	147 14 07	9189.2	10049.1	5.71
Carver's Island	43 56 55.96	69 19 12.51	46 06 13	Davis	226 03 49	6433.6	7035.6	4.00
			108 48 10	Muscongus	288 43 11	10145.2	11094.5	6.30
Hatchet Hill	43 58 23.27	69 21 01.18	318 02 00	Carver's Island	138 03 15	3623.1	3962.1	2.25
			17 10 24	Davis	197 09 15	7490.4	8191.2	4.65
Medumcook Hill	43 58 30.45	69 19 03.83	33 12 55	Davis	213 10 25	8817.3	9642.4	5.48
			3 48 01	Carver's Island	183 47 55	2922.0	3195.4	1.82
Cow Island, flag	43 57 40.47	69 23 11.19	245 29 02	Hatchet Hill	65 30 30	3184.6	3482.6	1.98
			353 16 02	Davis	173 16 23	5876.5	6426.4	3.65
Long Island	43 57 42.63	69 20 04.20	321 19 46	Carver's Island	141 20 22	1844.4	2017.0	1.15
			134 39 00	Hatchet Hill	314 38 20	1784.8	1951.8	1.11

GEOGRAPHICAL POSITIONS—Continued.

Section I.—Muscongus Bay, Me.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Martin's Point, flag	43 57 57.68	69 21 40.83	228 13 01	Hatchet Hill	48 13 29	1185.1	1296.0	0.74
			253 52 05	Medumcook Hill	73 53 54	3642.1	3983.1	2.26
Long Island, flag	43 57 05.69	69 20 26.92	280 14 48	Carver's Island	100 15 40	1685.8	1843.5	1.05
			162 18 54	Hatchet Hill	342 18 30	2513.2	2748.4	1.56
White house, chimney	43 57 17.77	69 20 08.38	212 40 32	Medumcook Hill	32 41 17	2664.5	2913.8	1.66
			186 54 51	Long Island	6 54 54	772.9	845.2	0.48
Chimney of red house on Long Island.	43 57 19.32	69 19 55.35	207 36 51	Medumcook Hill	27 37 27	2477.2	2709.0	1.54
			164 39 14	Long Island	344 39 08	746.0	815.8	0.46
Chimney of white house east of Long Island Station.	43 57 37.66	69 19 56.09	322 56 52	Carver's Island	142 57 22	1612.3	1763.1	1.00
			134 08 30	Hatchet Hill	314 07 45	2021.5	2210.6	1.26
Cupola of white house	43 58 51.92	69 19 48.61	9 13 48	Long Island	189 13 35	2167.1	2369.9	1.35
			347 19 37	Carver's Island	167 20 02	3668.3	4011.6	2.28
One-story white house, chimney	43 58 36.70	69 19 41.30	348 20 20	Carver's Island	168 20 40	3174.8	3471.8	1.97
			17 00 29	Long Island	197 00 13	1745.5	1908.8	1.08
Hornbeam Hill	43 58 39.22	69 17 38.90	83 46 28	Hatchet Hill	263 44 08	4537.9	4962.5	2.82
			33 14 54	Carver's Island	213 13 49	3811.2	4167.8	2.37
Chimney of white house east of cove.	43 57 50.65	69 18 08.81	40 05 02	Carver's Island	220 04 18	2205.8	2412.2	1.37
			135 02 21	Medumcook Hill	315 01 43	1735.2	1897.6	1.08
Chimney of red house on Burton's Island.	43 56 49.27	69 18 25.81	101 13 48	Carver's Island	281 13 16	1061.5	1160.8	0.66
			164 49 01	Medumcook Hill	344 48 35	3235.2	3537.9	2.01
Carver's Island, flag in tree	43 56 55.94	69 19 11.14	91 03 31	Carver's Island	271 03 30	30.6	33.5	0.02
			183 11 52	Medumcook Hill	3 11 57	2920.9	3194.2	1.81
Chimney of white house on northwest point.	43 57 42.44	69 20 22.90	269 09 29	Long Island	89 09 42	416.8	455.8	0.26
			145 54 16	Hatchet Hill	325 53 49	1521.7	1664.1	0.95
Old red house, chimney	43 58 33.51	69 21 18.58	271 47 34	Medumcook Hill	91 49 08	3004.6	3285.7	1.87
			309 11 01	Hatchet Hill	129 11 13	500.2	547.0	0.31
Chimney of white house on west shore of Hatchet Cove.	43 58 48.07	69 21 03.32	326 52 15	Long Island	146 52 56	2411.2	2636.8	1.50
			356 25 36	Hatchet Hill	176 25 37	766.6	838.3	0.48
Brick house, east chimney	43 58 20.45	69 20 07.42	257 43 00	Medumcook Hill	77 43 44	1450.5	1586.2	0.90
			356 29 05	Long Island	176 29 07	1169.3	1278.7	0.73
Chimney of red house, north of cove.	43 58 53.61	69 19 02.40	2 32 37	Medumcook Hill	182 32 36	715.0	781.9	0.44
			32 10 02	Long Island	212 09 19	2587.7	2829.8	1.61
Pemmaquid Shore, Me.								
GULL	43 52 39.17	69 24 37.35	217 01 29	Davis	37 02 50	4336.9	4742.7	2.69
Brown's Head	43 54 09.97	69 27 15.29	263 49 50	Davis	83 53 01	6171.0	6748.4	3.83
			308 27 54	Gull	128 29 44	4502.6	4923.9	2.80
Yellow Head	43 51 25.73	69 29 17.30	220 36 55	Hatchet Hill	40 42 39	16987.2	18576.7	10.55
			250 02 10	Gull	70 05 24	6647.0	7269.0	4.13
Lookout Hill	43 52 19.11	69 29 35.32	246 10 39	Davis	66 15 27	10121.7	11068.8	6.29
			264 38 56	Gull	84 42 23	6680.3	7305.3	4.15
Thomas McFarland's house, chimney.	43 52 05.57	60 29 07.42	123 51 48	Lookout Hill	303 51 29	750.0	820.2	0.47
			242 27 09	Davis	62 31 37	9741.3	10652.8	6.05
Little Island, flag	43 52 12.79	69 28 40.82	207 49 09	Brown's Head	27 50 08	4089.1	4471.8	2.54
			241 58 25	Davis	62 02 35	9111.9	9964.5	5.66
Long Cove, east entrance	43 52 09.66	69 28 08.00	212 16 57	Brown's Head	32 17 34	2201.8	2407.9	1.37
			250 56 31	Davis	71 00 18	7735.0	8458.8	4.81
Brown's Head, flag in tree	43 54 10.94	69 27 15.94	308 38 46	Gull	128 40 36	4532.5	4956.6	2.82
			334 02 53	Brown's Head	154 02 53	33.2	36.3	0.02
Flag on high hill west of Brown's Head.	43 54 12.37	69 27 37.34	228 43 29	Hatchet Hill	48 48 04	11750.4	12849.8	7.30
			305 34 05	Gull	125 36 10	4937.0	5399.0	3.07
Medomac River, Me.								
HUNGRY	44 00 21.06	69 21 57.80	....	....	....	....	....	....
STAHL	44 02 44.29	69 22 13.17	355 34 15	Hungry	175 34 26	4433.6	4848.4	2.76
BREMEN	44 01 44.88	69 22 18.78	349 45 23	Hungry	169 45 38	2628.2	2874.2	1.63
South Waldoboro	44 02 15.15	69 19 31.92	42 42 30	Hungry	222 40 49	4790.7	5239.0	2.98
			104 04 48	Stahl	284 02 56	3700.5	4046.7	2.30
Miller's Island	44 01 06.90	69 22 48.44	209 24 33	Bremen	29 24 54	1344.8	1470.6	0.84
			321 26 02	Hungry	141 26 37	1809.4	1978.7	1.12

GEOGRAPHICAL POSITIONS—Continued.

Section I.—Medomac River, Me.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Harris	44 00 30.08	69 23 16.04	208 55 02	Bremen	28 55 42	2636.7	2883.4	1.64
			208 24 40	Miller's Island	28 24 59	1292.0	1412.9	0.80
Heath	44 01 13.55	69 23 38.63	305 48 04	Hungry	125 49 14	2769.0	3028.0	1.72
			280 23 48	Miller's Island	100 24 23	1136.5	1242.8	0.71
Eastern Branch	44 01 56.49	69 23 27.12	325 57 37	Hungry	145 58 39	3553.8	3886.4	2.21
			330 37 18	Miller's Island	150 37 45	1756.2	1920.5	1.09
Brimstone Hill	44 03 08.78	69 19 39.77	77 31 33	Stahl	257 29 46	3497.3	3824.6	2.17
			53 49 52	Bremen	233 48 01	4385.9	4796.3	2.73
Lower Hungry	43 59 53.65	69 22 01.92	217 23 50	South Waldoboro	37 25 34	5498.5	6013.0	3,42
			124 15 17	Harris	304 14 25	1997.2	2184.1	1.24
Delno's Hill, flag in tree	44 00 15.61	69 20 48.83	97 46 17	Harris	277 44 35	3309.4	3619.1	2.06
			96 15 30	Hungry	276 14 42	1545.4	1690.0	0.96
Upper Long Island, flag in tree.	43 59 59.78	69 22 48.47	180 01 19	Miller's Island	0 01 19	2071.5	2265.3	1.29
			146 42 41	Harris	326 42 22	1118.7	1223.4	0.69
Bickmore's house, center chimney.	44 01 01.85	69 22 11.99	100 52 10	Miller's Island	280 51 45	826.6	903.9	0.51
			173 29 57	Bremen	353 29 52	1335.8	1460.7	0.83
Bickmore's barn, south apex	44 00 58.15	69 22 14.74	104 17 22	Heath	284 16 24	1927.7	2108.1	1.20
			138 10 44	Eastern Branch	318 09 54	2416.5	2642.6	1.50
Heath House, west chimney	44 00 58.17	69 23 40.98	231 47 23	Bremen	51 48 20	2329.8	2547.8	1.45
			257 00 52	Miller's Island	77 01 28	1200.5	1312.8	0.75
Havener House, center chimney.	44 01 35.44	69 22 46.42	59 51 47	Heath	239 51 11	1344.4	1470.2	0.84
			244 43 23	Bremen	64 43 42	680.6	744.3	0.42
Bright-yellow house	44 01 34.10	69 24 39.49	246 46 43	Eastern Branch	66 47 33	1753.2	1917.2	1.09
			288 44 06	Miller's Island	108 45 23	2611.6	2855.9	1.62
Old House, center chimney	44 01 47.57	69 24 43.04	296 10 33	Miller's Island	116 11 53	2844.0	3110.1	1.77
			260 44 30	Eastern Branch	80 45 23	1712.6	1872.8	1.06
Meeting-house, cupola	44 02 24.41	69 24 33.18	315 42 45	Miller's Island	135 43 58	3340.5	3653.0	2.08
			317 43 08	Hungry	137 44 56	5144.4	5625.7	3.20
Howard's red store, center chimney.	44 01 59.88	69 24 03.68	277 18 29	Eastern Branch	97 18 54	820.6	897.4	0.51
			317 24 04	Hungry	137 25 31	4142.5	4530.1	2.57
Red House, center chimney	44 02 04.57	69 23 42.47	306 09 46	Eastern Branch	126 09 57	422.8	462.4	0.26
			356 52 21	Heath	176 52 24	1576.6	1724.1	0.98
Long House, center chimney	44 02 39.97	69 23 22.22	7 47 41	Heath	187 47 30	2692.4	2944.3	1.67
			4 39 07	Eastern Branch	184 39 04	1345.9	1471.9	0.84
Eastern Branch House, center chimney.	44 02 02.33	69 22 47.37	37 10 30	Heath	217 09 54	1889.2	2066.0	1.17
			78 29 55	Eastern Branch	258 29 27	903.2	987.7	0.56
Harpswell Sound, Me.								
HARPSWELL SPIRE	43 47 58.33	69 58 51.42	....	....	....	....	....	....
BURNT LEDGE	43 47 55.99	69 49 44.73	....	....	....	....	....	....
YARMOUTH	43 46 56.63	69 54 27.00	253 47 02	Burnt Ledge	73 50 17	6570.7	7185.5	4.08
			107 52 53	Harpswell Spire	287 49 50	6210.0	6791.1	3.86
ORR	43 51 05.87	69 54 02.53	4 04 13	Yarmouth	184 03 56	7710.7	8432.2	4.79
			48 08 37	Harpswell Spire	228 05 17	8668.7	9479.8	5.39
Grover	43 50 01.89	69 53 08.38	310 28 15	Burnt Ledge	130 30 36	5983.7	6543.5	3.72
			17 05 26	Yarmouth	197 04 32	5981.2	6540.8	3.72
Butler	43 47 45.52	69 51 57.17	65 45 41	Yarmouth	245 43 57	3673.7	4017.4	2.28
			159 17 40	Grover	339 16 51	4499.0	4919.9	2.80
Burnt Ledge, Sullivan	43 47 51.80	69 50 07.98	73 38 21	Yarmouth	253 35 22	6035.6	6600.3	3.75
			134 53 58	Grover	314 51 53	5689.2	6221.6	3.54
Charles Orr	43 50 08.94	69 54 44.68	356 11 13	Yarmouth	176 11 25	5947.9	6504.4	3.70
			53 51 14	Harpswell Spire	233 48 23	6829.4	7468.4	4.24
Cranberry Ridge	43 51 27.52	69 55 18.49	291 29 25	Orr	111 30 18	1823.2	1993.8	1.13
			342 41 54	Charles Orr	162 42 17	2539.3	2776.9	1.58
McKinney	43 50 08.69	69 51 53.05	30 08 56	Yarmouth	210 07 09	6853.3	7494.6	4.26
			82 54 02	Grover	262 53 10	1695.8	1854.4	1.05
Three Islands	43 50 56.02	69 52 21.40	336 33 15	McKinney	156 33 35	1591.8	1740.8	0.99
			32 08 38	Grover	212 08 05	1972.5	2157.0	1.23
Rich's Mount	43 51 44.62	69 51 57.39	19 40 53	Three Islands	199 40 36	1592.7	1741.8	0.99
			66 50 16	Orr	246 48 49	3039.2	3323.6	1.89

GEOGRAPHICAL POSITIONS—Continued.

Section I.—Harpswell Sound, Me.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Basin	43 48 19.39	69 51 21.00	297 32 20	Burnt Ledge, Sullivan	117 33 10	1840.7	2013.0	1.14
			37 44 13	Butler	217 43 48	1321.0	1444.6	0.82
Dingley	43 49 10.26	69 52 34.94	207 25 20	McKinney	27 25 49	2031.8	2221.9	1.26
			154 52 51	Grover	334 52 28	1760.0	1924.7	1.09
Sheep Island	43 48 07.16	69 52 37.97	306 12 09	Butler	126 12 37	1130.2	1235.9	0.70
			48 14 33	Yarmouth	228 13 17	3267.7	3573.4	2.03
Crooker	43 49 56.41	69 51 33.23	94 33 34	Grover	274 32 28	2132.1	2331.6	1.33
			35 00 30	Yarmouth	214 58 30	6771.1	7404.7	4.21
Yellow square house, chimney	43 49 44.77	69 53 12.29	207 20 05	Three Islands	27 20 40	2475.2	2706.8	1.54
			335 28 07	Butler	155 28 59	4044.5	4422.9	2.51
Bush Island, flag	43 49 11.96	69 51 11.41	20 58 57	Butler	200 58 25	2856.5	3123.8	1.77
			120 32 23	Grover	300 31 02	3033.8	3317.7	1.88
Jenny's Nubble	43 49 29.90	69 51 41.66	63 01 03	Dingley	243 00 26	1335.8	1460.7	0.83
			168 00 14	McKinney	348 00 06	1223.9	1338.5	0.76
Birch Point, flag	43 49 33.03	69 51 53.03	179 58 15	McKinney	359 58 15	1100.7	1203.7	0.68
			1 36 03	Butler	181 36 00	3318.9	3629.4	2.06
McKinney's Hill, flag	43 50 31.22	69 51 51.35	62 15 53	Grover	242 15 00	1944.3	2126.2	1.21
			138 45 49	Three Islands	318 45 28	1018.0	1113.2	0.63
Hotel Church, flag-staff	43 47 30.73	69 53 16.55	191 00 05	Three Islands	11 00 43	6454.1	7058.0	4.01
			255 32 49	Butler	75 33 44	1832.3	2003.7	1.14
Flag in center of Long Island	43 49 58.63	69 52 24.85	351 26 21	Butler	171 26 40	4154.2	4542.9	2.58
			190 36 57	Rich's Mount	10 37 16	3328.3	3639.7	2.07
Northwest end of Long Island, flag.	43 50 15.08	69 52 35.91	349 22 22	Butler	169 22 49	4696.6	5136.0	2.92
			60 43 05	Grover	240 42 43	831.7	909.6	0.52
Black flag at head of cove	43 50 17.62	69 53 30.70	314 13 31	Grover	134 13 46	695.8	760.9	0.43
			11 28 20	Yarmouth	191 27 41	6328.9	6921.1	3.93
Chimney of red house, near Butler.	43 47 46.77	69 51 48.66	78 40 16	Butler	258 40 10	194.1	212.3	0.12
			172 51 48	Three Islands	352 51 25	5885.9	6436.7	3.66
West Bay	43 49 01.86	69 54 53.39	300 52 03	Butler	120 54 05	4588.5	5017.8	2.85
			351 18 41	Yarmouth	171 18 59	3909.5	4275.3	2.43
East Bay	43 49 48.45	69 53 40.72	11 02 23	Yarmouth	191 01 51	5402.3	5907.8	3.36
			48 29 30	West Bay	228 28 40	2168.4	2371.3	1.35
Totman	43 49 38.54	69 54 47.35	312 30 39	Butler	132 32 37	5159.4	5642.2	3.21
			354 47 18	Yarmouth	174 47 32	5017.3	5486.8	3.12
Northwest point of Snow's Island.	43 48 59.75	69 54 22.47	95 22 39	West Bay	275 22 18	694.1	759.1	0.43
			211 49 56	East Bay	31 50 25	1766.0	1931.3	1.10
Northeast point of Snow's Island.	43 49 04.06	69 54 10.31	85 57 57	West Bay	265 57 27	965.1	1055.4	0.60
			205 46 13	East Bay	25 46 33	1520.8	1663.1	0.95
East entrance of Orr's Cove	43 49 23.48	69 54 32.27	343 22 34	N. W. pt. of Snow's Isl'd.	163 22 41	763.3	834.7	0.47
			320 40 55	N. E. pt. of Snow's Isl'd.	140 41 10	775.2	847.7	0.48
Northwest point of Ben's Island.	43 49 12.76	69 53 56.73	75 08 05	West Bay	255 07 26	1310.0	1432.6	0.81
			198 00 04	East Bay	18 00 15	1157.7	1266.0	0.72
Head of Rich's Cove	43 49 41.08	69 53 45.04	16 38 53	N. W. pt. of Ben's Island.	196 38 45	912.3	997.6	0.57
			26 18 38	N. E. pt. of Snow's Isl'd.	206 18 21	1274.2	1393.4	0.79
South point of Small Island	43 49 21.71	69 53 59.57	347 05 38	N. W. pt. of Ben's Island.	167 05 40	283.6	310.1	0.18
			23 47 15	N. E. pt. of Snow's Isl'd.	203 47 08	595.4	651.1	0.37
East entrance of Mill Cove	43 49 24.02	69 54 19.25	48 09 11	West Bay	228 08 47	1024.0	1119.8	0.64
			5 28 52	N. W. pt. of Snow's Isl'd.	185 28 50	751.7	822.1	0.47
East entrance of Rich's Cove	43 49 22.61	69 53 46.55	36 47 55	N. W. pt. of Ben's Isl'd.	216 47 48	379.8	415.3	0.24
			84 34 42	S. point of small island	264 34 33	292.1	319.4	0.18
Mill Cove	43 49 34.87	69 54 25.86	336 16 41	E. entrance of Mill Cove.	156 16 46	365.7	399.9	0.23
			22 06 53	E. entr'ce of Orr's Cove.	202 06 49	379.6	415.1	0.24
West chimney of unpainted house east of northeast of fish-house.	43 49 12.70	69 53 26.60	80 13 31	West Bay	260 12 31	1968.1	2152.3	1.22
			164 02 38	East Bay	344 02 28	1147.3	1254.7	0.71
Totman, flag in tree	43 49 38.63	69 54 48.44	5 34 20	West Bay	185 34 17	1140.3	1247.0	0.71
			321 23 15	N. E. pt. of Snow's Isl'd.	141 23 41	1365.3	1493.0	0.85
Buoy on sunken ledge	43 48 54.80	69 54 36.23	243 29 33	N. W. pt. of Snow's Isl'd.	63 29 43	343.8	376.0	0.21
			119 28 20	West Bay	299 28 08	440.6	481.9	0.27
Tree	43 49 05.67	69 54 46.90	273 27 53	N. E. pt. of Snow's Isl'd.	93 28 18	820.0	896.7	0.51
			288 32 33	N. W. pt. of Snow's Isl'd.	108 32 50	574.6	628.3	0.36

GEOGRAPHICAL POSITIONS—Continued.

Section I.—Harpswell Sound, Maine.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Southwest corner of fish-house.	43 49 31.36	69 53 58.42	17 30 43 356 15 18	N. E. pt. of Snow's Isl'd N. W. pt. of Ben's Isl'd	197 30 35 176 15 19	883.4 575.4	966.0 629.2	0.55 0.36
South entrance of Davis' Cove	43 49 09.23	69 54 47.21	217 09 47 280 57 23	E. entr'ce of Orr's Cove N. E. pt. of Snow's Isl'd	37 09 57 100 57 49	552.2 840.1	603.9 918.7	0.34 0.52
Flag in tree on ridge	43 49 17.18	69 55 15.25	346 01 56 285 35 10	Yarmouth N. E. pt. of Snow's Isl'd	166 02 29 105 35 55	4469.4 1506.2	4887.6 1647.1	2.78 0.94
Chimney of house with red trimmings.	43 48 52.93	69 54 55.91	224 25 51 349 47 16	East Bay Yarmouth	44 26 43 169 47 36	2399.3 3646.7	2623.8 3987.9	1.49 2.27
Northwest corner of northeast fish-house.	43 49 21.95	69 53 38.49	55 09 55 89 07 15	N. W. pt. of Ben's Isl'd S. point of Small Island	235 09 42 269 07 00	496.7 471.1	543.1 515.2	0.31 0.29
Southwest corner of southeast fish-house.	43 49 16.69	69 53 42.35	152 45 30 73 55 24	E. entr'ce of Rich's Cove West Bay	332 45 27 253 54 35	205.3 1652.3	224.5 1806.9	0.13 1.03
Southeast corner of wharf on west shore.	43 49 14.72	69 54 49.86	290 24 30 307 03 45	N. E. pt. of Snow's Isl'd N. W. pt. of Snow's Isl,d	110 24 57 127 04 04	943.9 765.6	1032.3 837.2	0.59 0.48
Brick-kiln Cove	43 49 48.48	69 54 01.06	357 41 06 8 34 35	S. point of Small Island N. E. pt. of Snow's Isl'd	177 41 07 188 34 29	826.8 1386.4	904.1 1516.1	0.51 0.86
New Meadow River, Me.								
Holbrook	43 52 16.67	69 53 01.73	304 31 48 340 06 52	Rich's Mount Three Islands	124 32 33 160 07 20	1743.9 2647.5	1907.1 2895.2	1.08 1.65
No. 1, New Meadow River	43 53 36.79	69 53 44.57	338 51 12 4 55 14	Holbrook Orr	158 51 42 184 55 02	2651.0 4674.6	2899.1 5112.0	1.65 2.90
No. 2, New Meadow River	43 53 12.05	69 52 17.42	30 03 47 111 25 54	Holbrook No. 1, New Meadow Riv.	210 03 16 291 24 54	1974.9 2089.3	2159.7 2284.8	1.23 1.30
No. 3, New Meadow River	43 54 02.63	69 52 33.28	347 13 04 63 22 90	No. 2, New Meadow Riv. No. 1, New Meadow Riv.	167 13 15 243 22 01	1600.4 1779.6	1750.1 1946.1	0.99 1.11
No. 4, New Meadow River	43 54 57.35	69 52 06.59	19 25 36 4 15 11	No. 3, New Meadow Riv. No. 2, New Meadow Riv.	199 25 18 184 15 03	1790.4 3258.6	1957.9 3563.5	1.11 2.02
Holbrook's house, south chimney.	43 52 17.90	69 53 00.09	2 31 34 44 18 33	Grover Holbrook	182 31 28 224 18 32	4201.4 52.2	4594.5 57.1	2.61 0.03
Fish-house, entrance of bay	43 51 19.17	69 51 42.34	38 52 26 50 41 20	Grover Three Islands	218 51 26 230 40 53	3063.1 1127.2	3349.7 1232.7	1.90 0.70
Rich's Mount, white and black flag.	43 51 53.56	69 51 55.90	6 48 51 17 46 56	Rich's Mount Three Islands	186 48 50 197 46 38	277.4 1865.4	303.4 2039.9	0.17 1.16
Horsey's house, chimney	43 51 08.59	69 53 01.07	231 58 41 293 39 19	Rich's Mount Three Islands	51 59 25 113 39 46	1805.0 967.1	1973.9 1057.6	1.12 0.60
Foster's Point	43 51 28.54	69 52 42.53	243 47 23 334 49 31	Rich's Mount Three Islands	63 47 54 154 49 46	1123.4 1109.0	1228.5 1212.7	0.70 0.69
Woodward's house, cupola	43 52 31.01	69 53 49.07	292 41 44 326 15 42	Holbrook Three Islands	112 42 17 146 16 43	1145.7 3525.1	1252.9 3855.0	0.71 2.19
Woodward's barn, ventilator	43 52 29.80	69 53 49.79	290 40 06 325 42 23	Holbrook Three Islands	110 40 39 145 43 24	1146.7 3503.2	1254.0 3831.0	0.71 2.18
Chimney of large unpainted house.	43 53 02.11	69 53 26.45	258 43 56 338 30 50	No. 2, New Meadow Riv. Holbrook	78 44 44 158 31 07	1571.0 1507.1	1718.0 1648.1	0.98 0.94
New Meadow, spire	43 53 03.59	69 54 38.05	229 21 19 265 13 47	No. 1, New Meadow Riv. No. 2, New Meadow Riv.	49 21 56 85 15 24	1572.8 3149.6	1720.0 3444.3	0.98 1.96
Barn, cupola	43 54 44.86	69 52 17.22	211 38 09 0 05 14	No. 4, New Meadow Riv. No. 2, New Meadow Riv.	31 38 16 180 05 14	452.2 2864.7	494.5 3132.7	0.28 1.78
Harding's Hill, flag	43 54 58.65	69 52 07.97	3 40 04 322 18 02	No. 2, New Meadow Riv. No. 4, New Meadow Riv.	183 39 57 142 18 03	3296.3 50.5	3604.7 55.2	2.05 0.03
Flag in tree south of Great Hill.	43 53 12.41	69 51 17.33	89 32 16 132 26 38	No. 2, New Meadow Riv. No. 3, New Meadow Riv.	269 31 34 312 25 45	1341.2 2296.7	1466.7 2511.6	0.83 1.43
Southeast king-post, Bull Road Bridge.	43 54 23.07	69 51 55.95	52 52 30 167 20 46	No. 3, New Meadow Riv. No. 4, New Meadow Riv.	232 52 04 347 20 39	1044.8 1084.2	1142.5 1185.7	0.65 0.67
Rich's Mount, flag No. 2	43 52 11.27	69 51 10.70	51 43 58 34 13 11	Rich's Mount Three Islands	231 43 26 214 12 22	1327.9 2808.1	1452.1 3070.9	0.83 1.75
Flag above bay	43 52 42.00	69 50 05.02	54 47 26 42 58 07	Rich's Mount Three Islands	234 46 08 222 56 32	3070.8 4468.9	3358.2 4887.0	1.91 2.78
Quohog Bay and vicinity, Me.								
Head of Orr's Cove	43 50 08.71	69 54 29.46	91 13 48 198 49 48	Charles Orr Orr	271 13 38 18 50 07	340.0 1863.6	371.8 2037.9	0.21 1.16

GEOGRAPHICAL POSITIONS—Continued.

Section I.—Quohog Bay and vicinity, Me.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Whitmore	43 51 00.19	69 54 23.80	249 45 22	Orr	69 45 37	506.4	553.8	0.31
			16 25 55	Charles Orr	196 25 41	1648.7	1803.0	1.02
Prince's Point	43 50 31.01	69 55 55.83	246 57 32	Orr	66 58 51	2749.8	3007.1	1.71
			293 10 52	Charles Orr	113 11 41	1729.1	1890.9	1.07
Doughty	43 50 42.73	69 54 39.11	228 51 23	Orr	48 51 48	1085.0	1186.6	0.67
			147 31 59	Cranberry Ridge	327 31 32	1638.1	1791.4	1.02
Scofield	43 51 01.66	69 56 44.70	267 55 59	Orr	87 57 52	3624.0	3963.1	2.25
			310 55 03	Prince's Point	130 55 37	1444.3	1579.4	0.90
Doughty's Point	43 50 12.96	69 55 48.78	164 45 19	Prince's Point	344 45 14	599.5	655.6	0.37
			274 05 08	Charles Orr	94 05 52	1435.5	1569.8	0.89
Barnes Point	43 50 21.70	69 56 20.59	280 23 56	Charles Orr	100 25 02	2178.1	2381.9	1.35
			292 16 00	Doughty's Point	112 16 22	768.0	839.9	0.48
Ewins Narrows	43 48 55.89	69 56 47.03	192 34 20	Barnes Point	12 34 38	2713.3	2967.2	1.69
			201 16 59	Prince's Point	21 17 34	3150.2	3444.9	1.96
Flag in tree on ridge south of Long Reach.	43 48 46.10	69 55 44.72	175 36 53	Prince's Point	355 36 45	3247.0	3550.9	2.02
			207 40 43	Charles Orr	27 41 25	2887.2	3157.4	1.79
Prince's Point, flag in tree	43 50 34.82	69 55 53.87	126 07 35	Scofield	306 07 00	1405.0	1536.5	0.87
			248 55 08	Orr	68 56 25	2665.2	2914.6	1.66
J. B. Farren's house, chimney in center.	43 51 28.81	69 55 07.29	296 05 01	Orr	116 05 46	1610.3	1760.9	1.00
			80 52 50	Cranberry Ridge	260 52 42	253.2	276.9	0.16
White flag in tree	43 51 35.94	69 55 15.87	12 42 26	Cranberry Ridge	192 42 24	266.4	291.3	0.17
			345 27 11	Charles Orr	165 27 33	2773.4	3032.9	1.72
Square unpainted house, chimney in center.	43 52 21.53	69 56 40.48	303 29 33	Orr	123 31 22	4229.9	4625.7	2.63
			318 21 12	Doughty	138 22 36	4079.3	4461.0	2.53
Charles Orr's house, south chimney.	43 50 08.36	69 54 34.82	202 06 59	Orr	22 07 21	1915.7	2094.9	1.19
			174 50 09	Doughty	354 50 06	1065.2	1164.9	0.66
Arthur Reed's white house, chimney in center.	43 50 23.71	69 54 26.36	202 14 59	Orr	22 15 16	1405.7	1537.2	0.87
			41 55 48	Charles Orr	221 55 35	612.4	669.7	0.38
David Doughty's unpainted house, chimney.	43 50 24.91	69 55 07.51	228 56 32	Orr	48 57 17	1924.5	2104.6	1.20
			314 00 40	Charles Orr	134 00 56	709.0	775.3	0.44
Flag in tree southwest of Doughty's Point.	43 49 55.93	69 56 06.10	191 57 51	Prince's Point	11 57 58	1106.5	1210.0	0.69
			231 57 27	Orr	51 59 23	3503.8	3831.7	2.18
Hiram Wallace's barn, west gable.	43 50 10.66	69 55 51.16	272 02 03	Charles Orr	92 02 49	1486.0	1625.1	0.92
			170 32 52	Prince's Point	350 32 49	636.5	696.0	0.40
J. Jordan's barn, south gable	43 50 05.34	69 57 14.98	225 43 14	Cranberry Ridge	45 44 35	3638.4	3978.9	2.26
			268 05 04	Charles Orr	88 06 51	3359.2	3673.6	2.09
Jordan's house, north chimney.	43 50 15.53	69 57 10.22	273 33 43	Charles Orr	93 35 24	3257.6	3562.4	2.02
			273 09 49	Doughty's Point	93 10 45	1821.9	1992.4	1.13
Black and white flag on Prince's Bluff.	43 50 46.56	69 55 26.71	321 01 48	Charles Orr	141 02 17	1492.8	1632.5	0.93
			188 15 54	Cranberry Ridge	8 16 00	1277.3	1396.8	0.79
Barnes's white house, chimney in center.	43 50 35.84	69 56 50.41	286 27 05	Charles Orr	106 28 32	2928.7	3202.7	1.82
			297 51 29	Doughty's Point	117 52 12	1556.8	1702.4	0.97
Scofield's house, chimney at north end.	43 51 08.33	69 56 41.68	318 22 02	Prince's Point	138 22 34	1541.2	1685.4	0.96
			18 07 16	Scofield	198 07 14	216.7	236.9	0.13
William Anderson's house, chimney in center.	43 51 08.06	69 55 19.93	272 14 28	Orr	92 15 22	1729.9	1891.7	1.07
			336 39 15	Charles Orr	156 39 39	1987.1	2173.1	1.24
Orr's house, center chimney	43 51 08.10	69 54 28.07	118 01 16	Cranberry Ridge	298 00 41	1275.4	1394.7	0.79
			276 54 00	Orr	96 54 18	574.6	628.3	0.36
Vane in tree	43 51 09.25	69 56 44.43	317 23 43	Prince's Point	137 24 17	1603.3	1753.3	1.00
			1 28 30	Scofield	181 28 30	234.2	256.1	0.15
Coffin's house, center chimney	43 50 24.62	69 54 58.04	217 06 06	Doughty	37 06 19	700.5	766.0	0.44
			328 21 47	Charles Orr	148 21 56	568.6	621.8	0.35
Pennell's house, north chimney.	43 52 00.37	69 57 16.99	291 09 20	Orr	111 11 35	4656.5	5092.2	2.89
			290 57 27	Cranberry Ridge	110 58 50	2833.4	3098.5	1.76
Kennebec River, Me.								
HODGKINS	43 58 41.97	69 48 26.67						
MAXWELL	44 02 11.42	69 50 14.17	339 40 08	Hodgkins	159 41 23	6895.0	7540.2	4.28
Costelow	44 02 51.38	69 45 45.48	25 00 56	Hodgkins	204 59 04	8494.8	9289.6	5.28
			78 22 41	Maxwell	258 19 35	6107.1	6678.6	3.79

GEOGRAPHICAL POSITIONS—Continued.

Section I.—Kennebec River, Me.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Richmond	44 05 22.73	69 48 10.55	325 20 30	Costelow	145 22 11	5678.3	6209.6	3.53
			24 59 35	Maxwell	204 58 09	6513.9	7123.4	4.05
Houdlette	44 05 00.93	69 45 53.93	357 18 25	Costelow	177 18 31	4002.9	4377.5	2.49
			47 56 01	Maxwell	227 53 00	7804.5	8534.7	4.85
Hathorn's Hill	44 05 49.53	69 46 49.39	320 34 14	Houdlette	140 34 52	1942.6	2124.3	1.21
			65 22 44	Richmond	245 21 48	1985.8	2171.6	1.23
Theobald	44 05 28.05	69 45 44.15	14 33 53	Houdlette	194 33 46	864.7	945.6	0.54
			87 07 57	Richmond	267 06 15	3260.4	3565.4	2.03
Widow's Hill	44 06 59.98	69 45 00.66	18 49 18	Theobald	198 48 48	2998.6	3279.2	1.86
			48 02 29	Hathorn's Hill	228 01 13	3251.9	3556.2	2.02
Wilson	44 06 32.43	69 46 36.17	248 10 02	Widow's Hill	68 11 09	2287.7	2501.7	1.42
			329 47 47	Theobald	149 48 23	2300.0	2515.2	1.43
Hagar	44 08 02.13	69 45 45.73	334 31 23	Widow's Hill	154 31 54	2329.4	2547.4	1.45
			20 47 52	Wilson	200 47 16	3159.2	3454.8	1.96
Meserve	44 08 43.32	69 44 07.74	20 15 04	Widow's Hill	200 14 27	3399.2	3717.3	2.11
			39 15 23	Wilson	219 13 40	5216.0	5704.1	3.24
Woodward	44 08 17.59	69 45 40.62	248 57 04	Meserve	68 58 09	2211.7	2418.7	1.37
			339 38 43	Widow's Hill	159 39 11	2554.7	2793.7	1.59
Layton's Hill	44 10 21.40	69 45 28.70	329 16 16	Meserve	149 17 12	3521.0	3850.5	2.19
			3 58 05	Woodward	183 57 57	3830.1	4188.5	2.38
Telegraph Hill	44 10 26.66	69 44 21.95	23 42 08	Woodward	203 41 13	4349.8	4756.8	2.70
			83 45 53	Layton's Hill	263 45 07	1491.4	1630.9	0.93
Iron Hill	44 12 44.51	69 46 46.13	323 01 29	Telegraph Hill	143 03 09	5324.5	5822.7	3.31
			349 58 36	Woodward	169 59 22	8365.1	9147.8	5.20
Winter's Hill	44 16 53.17	69 44 06.52	1 38 44	Telegraph Hill	181 38 33	11933.6	13050.2	7.41
			24 47 01	Iron Hill	204 45 10	8451.7	9242.6	5.25
Perkins	44 16 18.14	69 47 26.46	256 16 36	Winter's Hill	76 18 56	4563.0	4990.0	2.84
			352 16 09	Iron Hill	172 16 37	6653.6	7276.1	4.13
Burnt Hill	44 19 13.20	69 46 47.21	320 29 32	Winter's Hill	140 31 24	5600.0	6124.0	3.48
			9 09 02	Perkins	189 08 35	5472.2	5984.2	3.40
Beacon	44 02 48.27	69 47 09.85	202 24 46	Houdlette	22 25 39	4429.4	4843.9	2.75
			267 03 49	Costelow	87 04 48	1880.4	2056.3	1.17
Swan Island 1	44 03 53.60	69 47 29.71	161 43 36	Richmond	341 43 08	2897.4	3168.5	1.80
			309 36 39	Costelow	129 37 51	3011.4	3293.1	1.87
Blair	44 03 39.70	69 45 14.73	98 08 33	Swan Island 1	278 06 59	3034.1	3318.0	1.89
			160 49 29	Houdlette	340 49 02	2654.6	2903.0	1.65
Thompson's red barn	44 04 08.82	69 48 18.35	184 20 50	Richmond	4 20 55	2287.8	2501.8	1.42
			243 23 39	Houdlette	63 25 19	3593.2	3929.4	2.23
Richmond, brown spire	44 05 16.79	69 47 59.62	279 55 04	Houdlette	99 56 31	2838.4	3104.0	1.76
			27 38 14	Maxwell	207 36 40	6457.3	7061.5	4.01
Methodist church, clock-spire	44 05 14.69	69 47 52.03	327 30 26	Costelow	147 31 54	5243.3	5733.9	3.26
			29 13 45	Maxwell	209 12 06	6480.4	7086.7	4.03
Congregationalist church-spire	44 05 08.33	69 47 55.00	325 42 04	Costelow	145 43 34	5116.1	5594.8	3.18
			29 34 37	Maxwell	209 33 00	6277.1	6864.5	3.90
Cemetery, flag-staff	44 06 14.56	69 45 42.72	213 42 49	Widow's Hill	33 43 18	1685.1	1842.8	1.05
			1 16 46	Theobald	181 16 45	1436.8	1571.2	0.89
Hathorn's barn, southeast gable.	44 05 31.24	69 46 48.02	81 52 38	Richmond	261 51 41	1854.3	2027.8	1.15
			221 03 44	Widow's Hill	41 04 59	3633.9	3974.0	2.26
David Reed's house, chimney	44 05 08.23	69 47 01.05	278 35 59	Houdlette	98 36 46	1509.6	1650.8	0.94
			217 48 27	Widow's Hill	37 49 51	4367.6	4776.3	2.71
Swan Island 3	44 05 00.60	69 47 28.93	221 48 29	Widow's Hill	41 50 12	4945.2	5407.9	3.07
			250 01 15	Theobald	70 02 28	2479.9	2711.9	1.54
Adkin's barn, south gable	44 11 19.86	69 45 26.61	3 10 15	Woodward	183 10 05	5633.5	6160.6	3.50
			1 28 19	Layton's Hill	181 28 18	1804.8	1973.6	1.12
Gardiner Congreg'nalist church, white spire.	44 13 38.16	69 46 12.20	24 27 46	Iron Hill	204 27 22	1819.0	1989.2	1.13
			204 50 32	Winter's Hill	24 52 00	6632.6	7253.2	4.12
Dunfry	44 12 53.14	69 46 10.72	331 52 35	Telegraph Hill	151 53 51	5125.3	5604.9	3.18
			165 08 05	Perkins	345 07 12	6546.2	7158.7	4.07
Gardiner Methodist church, spire.	44 13 55.02	69 46 11.38	339 17 38	Telegraph Hill	159 18 54	6874.0	7517.2	4.27
			206 43 15	Winter's Hill	26 44 42	6157.0	6733.2	3.83

GEOGRAPHICAL POSITIONS—Continued.

Section I.—Kennebec River, Me.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Gardiner Universalist church, spire.	44 13 41.18	69 46 03.31	28 31 40	Iron Hill	208 31 10	1990.5	2176.7	1.24
			203 36 16	Winter's Hill	23 37 37	6466.9	7072.0	4.02
Gardiner Episcopal church, spire.	44 13 38.26	69 46 09.27	26 15 41	Iron Hill	206 15 15	1849.6	2022.7	1.15
			204 20 31	Winter's Hill	24 21 57	6602.7	7220.6	4.10
Gardiner Catholic church, spire.	44 13 32.49	69 46 10.80	27 54 30	Iron Hill	207 54 05	1675.7	1832.5	1.04
			203 58 56	Winter's Hill	24 00 23	6779.1	7413.5	4.21
Bodge	44 09 30.87	69 44 56.89	204 16 00	Telegraph Hill	24 16 24	1888.5	2065.2	1.17
			23 15 20	Woodward	203 14 49	2461.5	2691.8	1.53
Lapham	44 12 20.21	69 45 06.80	5 43 54	Woodward	185 43 30	7525.3	8229.4	4.68
			344 07 38	Telegraph Hill	164 08 09	3642.9	3983.8	2.26
Pittston spire	44 13 49.98	69 45 34.98	38 01 20	Iron Hill	218 00 30	2564.4	2804.3	1.59
			199 07 57	Winter's Hill	19 08 59	5984.0	6543.9	3.72
Augusta Free Will Baptist church, spire.	44 19 08.17	69 46 27.36	2 00 54	Iron Hill	182 00 41	11848.0	12956.6	7.36
			109 25 55	Burnt Hill	289 25 41	466.4	510.0	0.29
Capitol, flag-staff	44 18 24.73	69 46 34.25	310 46 45	Winter's Hill	130 48 28	4325.4	4730.1	2.69
			16 30 13	Perkins	196 29 37	4074.8	4456.0	2.53
Augusta Congregationalist church, spire.	44 18 59.74	69 46 13.25	324 16 02	Winter's Hill	144 17 31	4811.3	5261.5	2.99
			118 52 45	Burnt Hill	298 52 21	859.4	939.8	0.53
Hunt	44 15 44.48	69 45 44.45	225 40 45	Winter's Hill	45 41 53	3034.7	3318.6	1.89
			114 40 26	Perkins	294 39 15	2489.3	2722.3	1.55
Augusta Baptist church, spire	44 18 52.25	69 46 17.04	134 01 51	Burnt Hill	314 01 30	929.9	1016.9	0.58
			321 46 39	Winter's Hill	141 48 10	4677.1	5114.8	2.91
Insane asylum, chimney	44 18 08.92	69 45 53.23	31 09 43	Perkins	211 08 38	3995.0	4368.8	2.48
			148 54 56	Burnt Hill	328 54 18	2316.5	2533.2	1.44
Foster's mill, chimney	44 05 18.98	69 47 29.17	284 43 17	Houdlette	104 44 23	2190.6	2395.6	1.36
			263 09 25	Theobald	83 10 38	2352.6	2572.7	1.46
Prescott's house, chimney	44 06 21.53	69 45 43.77	218 54 52	Widow's Hill	38 55 22	1525.9	1668.7	0.95
			179 14 34	Hagar	359 14 33	3290.5	3598.3	2.04
Hallowell Methodist church, spire, (gilt ball.)	44 17 09.70	69 47 17.55	7 04 27	Perkins	187 04 21	1603.3	1753.3	1.00
			276 50 59	Winter's Hill	96 53 12	4265.8	4664.9	2.65
Hallowell, white spire	44 16 54.83	69 47 10.98	342 35 53	Telegraph Hill	162 37 51	12553.3	13727.9	7.80
			187 02 03	Burnt Hill	7 02 20	4302.5	4705.0	2.67
Farmington, Me.								
HARRIS	44 39 53.57	69 08 32.90						
MOUNT BLUE	44 43 40.13	70 20 11.91	273 48 23	Harris	94 38 47	94898.2	103777.9	58.96
Bannock	44 44 00.39	70 02 02.57	275 50 28	Harris	96 28 05	71068.0	77717.8	44.15
			88 36 44	Mount Blue	268 23 57	23975.1	26218.5	14.90
Farmington	44 40 13.94	70 09 28.93	234 31 50	Bannock	54 37 04	12057.6	13185.8	7.49
			114 16 20	Mount Blue	294 08 48	15519.0	16971.1	9.64
Stewart	44 40 18.28	70 08 54.43	112 44 21	Mount Blue	292 36 24	16162.2	17674.5	10.04
			80 00 22	Farmington	259 59 57	771.3	843.4	0.48
Farmington, observatory	44 40 21.44	70 08 56.04	72 17 23	Farmington	252 17 00	760.2	831.3	0.47
			339 59 41	Stewart	159 59 42	103.6	113.3	0.06
Court-house	44 40 16.31	70 08 46.77	112 42 30	Mount Blue	292 34 28	16341.4	17870.4	10.15
			85 29 49	Farmington	265 29 19	931.3	1018.4	0.58
Saco Bay, Me., from Wells to Richmond Island.								
COLE'S HILL	43 20 34.07	70 33 56.92						
KENNEBUNK POINT	43 20 29.31	70 27 39.24	91 01 32	Cole's Hill	270 57 13	8507.2	9303.2	5.29
Wellstown	43 17 14.96	70 34 03.15	235 13 48	Kennebunk Point	55 18 11	10525.8	11510.7	6.54
			222 39 40	Boothbey	42 42 48	9126.1	9980.1	5.67
Merrill	43 23 49.17	70 28 23.69	14 58 46	Boothbey	194 58 01	5647.4	6175.8	3.51
			336 31 03	Summit	156 31 54	4197.0	4589.8	2.61
School-House Hill	43 22 14.98	70 26 20.02	270 11 46	Stage Island	90 12 49	2069.0	2262.5	1.29
			49 41 28	Summit	229 40 54	1458.1	1594.6	0.91
Holman's Point	43 26 51.19	70 20 12.26	36 03 41	Stage Island	216 00 31	10549.0	11536.0	6.55
			44 11 01	School-House Hill	224 06 48	11878.3	12989.8	7.38
Little River	43 23 38.43	70 23 31.96	55 46 07	School-House Hill	235 44 12	4575.8	5003.9	2.84
			54 18 28	Summit	234 15 59	6027.8	6591.8	3.75

GEOGRAPHICAL POSITIONS—Continued.

Section I.—Saco Bay, Me., from Wells to Richmond Island.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Andrew Huff's barn, cupola	43 21 47.90	70 26 20.57	84 24 27	Summit	264 23 53	1105.0	1208.4	0.69
			228 02 16	Little River	48 04 12	5103.0	5580.5	3.17
Oakridge	43 26 53.15	70 26 05.16	270 24 08	Holman's Point	90 28 11	7934.2	8676.6	4.93
			2 13 58	School-house Hill	182 13 48	8590.0	9393.8	5.34
Jordan's Island	43 30 16.41	70 18 20.66	21 36 52	Holman's Point	201 35 36	6811.4	7448.7	4.23
			59 02 29	Oakridge	238 57 10	12177.8	13317.2	7.57
Saco Hill	43 33 08.26	70 21 14.37	323 38 55	Jordan's Island	143 40 55	6582.7	7198.7	4.09
			353 09 24	Holman's Point	173 10 07	11719.1	12815.7	7.28
Clarke's house, south chimney	43 20 12.71	70 32 44.46	265 42 36	Kennebunk Point	85 46 05	6893.2	7538.2	4.28
			112 00 59	Cole's Hill	292 00 09	1760.3	1925.0	1.09
Atlantic House, cupola	43 17 35.03	70 33 45.20	236 51 01	Kennebunk Point	56 55 12	9844.3	10765.4	6.12
			177 15 54	Cole's Hill	357 15 46	5531.4	6048.9	3.44
Wentworth's barn, cupola	43 20 51.24	70 29 53.47	40 09 11	Wellstown	220 06 20	8728.3	9545.0	5.42
			266 27 56	Boothbey	86 28 13	563.2	615.9	0.35
Fishing-house, flag-staff	43 20 24.86	70 29 44.19	267 11 56	Kennebunk Point	87 13 22	2817.5	3081.1	1.75
			92 53 01	Cole's Hill	272 50 08	5698.9	6232.1	3.54
Fishing-Rock Spindle	43 20 09.60	70 28 26.21	240 06 30	Kennebunk Point	60 07 02	1220.3	1334.5	0.76
			95 49 15	Cole's Hill	275 45 28	7487.7	8188.3	4.65
Butland's house, middle chimney.	43 17 13.35	70 34 05.42	235 09 55	Kennebunk Point	55 14 20	10596.4	11587.9	6.58
			222 41 14	Boothbey	42 44 24	9197.2	10057.8	5.71
Kennebunkport light	43 20 44.32	70 28 14.20	300 28 20	Kennebunk Point	120 28 44	913.5	998.9	0.57
			98 26 31	Boothbey	278 25 40	1692.0	1850.3	1.05
School-house, chimney	42 22 14.68	70 26 19.33	269 56 04	Stage Island	89 57 07	2053.2	2245.3	1.28
			50 22 00	Summit	230 21 26	1463.9	1600.9	0.91
Curtis Cove	43 24 23.11	70 23 25.83	25 03 44	Stage Island	205 02 48	4372.5	4781.6	2.72
			44 46 20	School-House Hill	224 44 20	5567.7	6088.6	3.46
Clement Stone's house, middle chimney.	43 22 05.83	70 25 39.49	107 12 31	School-House Hill	287 12 03	955.3	1044.7	0.59
			256 36 47	Stage Island	76 37 22	1188.8	1300.0	0.74
George Emmons' house, middle chimney.	43 24 15.70	70 23 52.66	337 56 48	Little River	157 57 02	1240.5	1356.5	0.77
			18 29 28	Stage Island	198 28 50	3935.5	4303.7	2.45
Charles Cleaves' house, west apex.	43 23 57.11	70 23 35.00	353 15 39	Little River	173 15 41	580.2	634.5	0.36
			194 24 54	Curtis Cove	14 25 00	828.6	906.1	0.51
Biddeford Congregationalist church, spire.	43 29 32.52	70 27 05.36	263 23 41	Jordan's Island	83 29 42	11864.4	12974.5	7.37
			298 09 45	Holman's Point	118 14 29	10534.8	11520.5	6.55
Biddeford Baptist church, spire	43 29 38.82	70 27 09.30	264 22 10	Jordan's Island	84 28 14	11931.6	13048.0	7.41
			298 51 17	Holman's Point	118 56 04	10705.3	11707.0	6.65
Johnson's house, east chimney	43 29 06.10	70 22 51.23	250 19 49	Jordan's Island	70 22 55	6454.0	7057.9	4.01
			319 20 54	Holman's Point	139 22 43	5486.3	5999.7	3.41
Eagle Island, tree	43 28 45.65	70 21 13.61	338 40 06	Holman's Point	158 40 48	3791.6	4146.3	2.36
			179 52 48	Saco Hill	359 52 47	8103.7	8861.9	5.04
Staple's cupola	43 31 02.15	70 22 21.71	284 35 18	Jordan's Island	104 38 04	5594.7	6118.1	3.48
			339 24 05	Holman's Point	159 25 34	8272.3	9046.3	5.14
Blue Point Hill House, south chimney.	43 32 55.40	70 21 02.53	323 27 11	Jordan's Island	143 29 02	6105.9	6677.3	3.79
			354 15 26	Holman's Point	174 16 01	11295.8	12352.7	7.02
Richmond Island House, cupola	43 32 34.62	70 14 00.30	53 54 51	Jordan's Island	233 51 52	7236.6	7913.7	4.50
			38 17 26	Holman's Point	218 13 10	13495.5	14758.3	8.39
Butland	43 17 11.46	70 34 01.92	3 59 38	Bald Head Cliff	183 59 22	7413.3	8107.0	4.61
			36 28 31	Ogunquit	216 27 16	4156.3	4545.2	2.58
Donnell	43 15 58.53	70 35 43.01	225 21 00	Butland	45 22 10	3203.4	3503.1	1.99
			341 03 43	Bald Head Cliff	161 04 37	5438.6	5947.5	3.38
Maxwell	43 16 18.41	70 36 12.41	240 53 40	Butland	60 55 10	3366.8	3681.8	2.09
			337 07 53	Bald Head Cliff	157 09 07	6249.0	6833.7	3.88
Butland Island	43 18 05.76	70 33 46.56	11 40 28	Butland	191 40 17	1710.7	1870.8	1.06
			44 48 02	Maxwell	224 46 22	4667.0	5103.7	2.90
Congregationalist church, spire	43 18 04.12	70 34 51.60	16 38 57	Donnell	196 38 22	4045.0	4423.5	2.51
			268 00 04	Butland Island	88 00 49	1466.5	1603.7	0.91
Pequauket, cupola of house	44 06 19.60	71 05 20.22	333 32 42	Ossipee	153 47 24	64127.7	70128.1	39.84
			266 40 30	Sebattis	87 22 57	81424.9	89043.9	50.60

GEOGRAPHICAL POSITIONS—Continued.

Section I.—Cambridge, Mass.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Cloverden Station	42 22 45.56	71 06 57.11	107 30 12	Cambridge Observatory	287 29 55	610.6	667.8	0.38
			249 00 41	Somerville Church	69 01 39	2106.1	2303.2	1.31
Cloverden Observatory	42 22 44.31	71 06 56.59	154 01 08	Cloverden Station	334 01 07	43.0	47.0	0.03
Museum	42 22 42.54	71 06 35.01	239 46 04	Somerville Church	59 46 47	1682.8	1840.3	1.05
			104 11 22	Cambridge Observatory	284 10 50	1129.2	1234.9	0.70
Nantucket Island.								
Brant Point light	41 17 20.90	70 05 13.12	101 55 44	Nantucket Cliff	281 54 52	1883.1	2059.3	1.17
			33 46 06	South towered church	213 45 51	982.9	1074.9	0.61
Folger	41 17 14.71	70 05 55.08	123 48 17	Nantucket Cliff	303 47 52	1042.4	1139.9	0.65
			325 31 17	South towered church	145 31 29	759.6	830.7	0.47
Nantucket, north towered church.	41 17 07.63	70 05 46.72	329 59 13	South towered church	149 59 20	470.9	515.0	0.29
			138 20 34	Folger	318 20 29	291.8	319.1	0.18
Monomoy light of 1857	41 33 31.54	69 59 17.40	115 33 10	Shootflying	295 19 06	32577.6	35625.9	20.24
			18 54 12	Nantucket Cliff	198 49 24	31230.2	34152.4	19.40
Cape Cod, Mass.								
SCARGO	41 44 20.31	70 10 28.39	....	....	....	....	....	....
MILL HILL	41 46 32.00	69 59 45.41	74 45 45	Scargo	254 38 37	15396.6	16837.2	9.57
CHATHAM	41 41 48.52	69 58 26.81	105 45 06	Scargo	285 37 05	17321.8	18942.6	10.76
			168 16 29	Mill Hill	348 15 36	8931.2	9766.9	5.55
Marsh	41 43 49.75	69 55 18.34	49 22 09	Chatham	229 20 04	5741.4	6278.6	3.57
			129 04 37	Mill Hill	309 01 39	7944.4	8687.7	4.94
Pochet	41 46 37.83	69 56 04.49	348 22 40	Marsh	168 23 11	5293.6	5788.9	3.29
			88 00 01	Mill Hill	267 57 34	5104.7	5582.3	3.17
Eldridge	41 44 32.71	69 58 18.12	287 40 43	Marsh	107 42 43	4360.2	4768.2	2.71
			151 17 18	Mill Hill	331 16 20	4196.2	4588.9	2.61
Sampson	41 45 19.59	69 56 38.84	57 46 41	Eldridge	237 45 35	2711.4	2965.1	1.68
			198 11 24	Pochet	18 11 47	2540.8	2778.6	1.58
Old Harbor	41 42 17.75	69 55 39.51	138 39 12	Eldridge	318 37 26	5547.0	6066.1	3.45
			76 53 21	Chatham	256 51 30	3971.4	4343.0	2.47
Camp	41 43 57.41	69 59 11.69	345 22 28	Chatham	165 22 58	4109.2	4493.7	2.55
			228 39 21	Eldridge	48 39 57	1648.8	1803.1	1.02
Basin	41 39 46.29	69 56 20.06	142 09 05	Chatham	322 07 41	4775.8	5222.6	2.97
			191 20 40	Old Harbor	11 21 07	4765.6	5211.5	2.96
Pine	41 40 06.35	69 59 13.92	199 03 54	Chatham	19 04 25	3334.5	3646.5	2.07
			278 44 04	Basin	98 46 00	4068.8	4449.5	2.53
Mosquito	41 39 24.70	69 57 11.01	158 26 52	Chatham	338 26 02	4770.2	5216.5	2.96
			240 31 49	Basin	60 32 23	1353.8	1480.5	0.84
Shell	41 37 50.58	69 57 19.86	201 10 52	Basin	21 11 32	3828.4	4186.6	2.38
			157 47 58	Pine	327 46 42	4950.6	5413.9	3.08
Cove	41 36 53.94	69 58 13.59	206 17 05	Basin	26 18 20	5930.4	6485.3	3.68
			197 17 29	Mosquito	17 18 10	4870.8	5326.6	3.03
Chatham flag-staff	41 40 41.58	69 57 01.91	212 42 02	Old Harbor	32 42 57	3526.2	3856.2	2.19
			136 27 27	Chatham	316 26 31	2849.1	3115.7	1.77
Chatham, new spire	41 40 56.35	69 57 20.14	222 48 14	Old Harbor	42 49 21	3423.4	3743.7	2.13
			59 38 26	Pine	239 37 10	3050.1	3335.5	1.90
Strong	41 43 10.30	69 57 08.03	35 49 36	Chatham	215 48 46	3111.5	3402.6	1.93
			244 20 34	Marsh	64 21 54	2811.8	3074.9	1.75
Crow's Lookout	41 43 04.78	69 58 03.89	12 41 39	Chatham	192 41 25	2411.5	2637.1	1.50
			250 03 13	Marsh	70 05 03	4069.6	4450.4	2.53
Sipson's Island	41 44 07.11	69 57 30.45	208 03 59	Sampson	28 04 33	2533.9	2771.0	1.57
			125 38 40	Eldridge	305 38 08	1355.3	1482.1	0.84
Nameq oi	41 45 24.39	69.57 20.89	315 52 00	Marsh	135 53 21	4066.8	4447.3	2.53
			278 39 36	Sampson	98 40 04	982.6	1074.5	0.61
Mayo	41 45 58.02	69.56 48.85	38 05 27	Eldridge	218 04 28	3343.4	3656.2	2.08
			219 49 10	Pochet	39 49 40	1599.3	1749.0	0.99
Cummings's flag-staff	41 47 10.03	69 56 42.77	318 19 48	Pochet	138 20 14	1329.5	1453.9	0.83
			358 28 25	Sampson	178 [illegible] 28	3408.2	3727.1	2.12
Mayo's House, south chimney	41 47 18.55	69 56 24.21	340 04 10	Pochet	160 04 23	1335.9	1460.9	0.83
			5 15 40	Sampson	185 15 30	3685.2	4039.0	2.29

GEOGRAPHICAL POSITIONS—Continued.

Section I.—Cape Cod, Mass.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Atwood	41 45 09.24	70 04 02.81	80 25 15	Scargo	260 20 58	9034.5	9879.8	5.61
			246 44 05	Mill Hill	66 46 56	6469.6	7075.0	4.02
Billingsgate light, 1858	41 52 16.13	70 03 48.37	332 08 27	Mill Hill	152 11 09	12004.8	13128.0	7.46
			32 12 32	Scargo	212 08 05	17340.0	18962.5	10.77
Rock Point	41 46 10.80	70 04 24.52	264 10 56	Mill Hill	84 14 02	6478.3	7084.5	4.03
			345 12 29	Atwood	165 12 43	1964.3	2148.1	1.22
Orleans 2	41 47 30.45	70 00 30.08	330 13 41	Mill Hill	150 14 11	2077.2	2271.6	1.29
			65 36 35	Rock Point	245 33 59	5944.5	6500.7	3.69
Hopkins	41 45 59.89	70 02 30.01	97 15 39	Rock Point	277 14 23	2665.7	2915.1	1.66
			255 32 55	Mill Hill	75 24 45	3928.0	4295.5	2.44
Sears	41 44 36.17	70 07 35.55	83 01 56	Scargo	263 00 01	4023.4	4399.8	2.50
			236 29 34	Rock Point	56 31 41	5291.5	5786.6	3.29
North Dennis 2	41 44 40.22	70 12 08.28	219 19 06	Billingsgate light, 1858	39 24 39	18191.7	19893.9	11.30
			284 53 20	Scargo	104 54 27	2388.1	2611.6	1.48
Brewster, Orthodox Church spire.	41 45 41.10	70 04 35.80	195 52 23	Rock Point	15 52 31	952.7	1041.9	0.59
			256 47 42	Mill Hill	76 50 55	6887.7	7532.2	4.28
Harwich belfry	41 41 10.24	70 04 14.44	344 48 47	Harwich Port	164 49 07	2592.7	2835.3	1.61
			72 21 32	Hyannis	252 12 10	20178.0	22066.1	12.54
Indian Hill	41 52 56.00	70 31 40.47	136 10 47	Manomet	316 08 29	6867.8	7510.4	4.27
			169 22 50	Holmes	349 22 25	4659.4	5095.4	2.90
Plymouth Cliff	41 49 38.48	70 32 15.98	314 01 40	Shootflying	134 09 31	22758.0	24887.4	14.14
			287 53 18	Scargo	108 07 49	31746.6	34717.1	19.73
East Plymouth	41 52 55.99	70 31 40.49	324 39 04	Shootflying	144 46 32	26864.2	20377.9	16.70
			298 19 58	Scargo	118 34 06	33392.0	36516.5	20.75
Provincetown, Baptist church belfry.	42 03 25.39	70 10 18.30	325 49 14	Griffin's Island	145 53 38	16144.0	17654.6	10.03
			253 10 34	Stout	73 12 39	4489.2	4909.3	2.79
School-house at Long Point	42 01 19.63	70 10 33.72	221 55 40	Stout	41 57 56	6961.2	7612.5	4.33
			315 09 17	Griffin's Island	135 13 51	13364.6	14615.1	8.30
South Wellfleet, Methodist meeting-house.	41 54 22.44	69 58 46.18	116 15 57	Griffin's Island	296 12 37	7664.3	8381.4	4.76
			92 50 19	Blackfish Creek	272 49 01	2701.6	2954.3	1.68
Fish-house, north gable	41 38 17.20	70 10 16.72	105 06 43	Bass River	285 05 41	2253.4	2464.2	1.40
			246 38 06	South Dennis	66 39 43	3674.3	4018.1	2.28
Narragansett Bay, R. I.								
CONANICUT NORTH	41 34 22.64	71 21 58.91						
PINE HILL	41 37 58.27	71 20 14.80	19 55 44	Conanicut North	199 54 35	7075.2	7737.2	4.40
Quonsett, 1863	41 35 14.69	71 24 02.06	226 10 28	Pine Hill	46 12 59	7290.2	7972.3	4.53
			299 21 51	Conanicut North	119 23 12	3273.3	3579.6	2.03
Calf Pasture	41 37 38.43	71 23 58.03	335 26 42	Conanicut North	155 28 01	6639.9	7261.2	4.13
			263 13 29	Pine Hill	83 15 57	5202.5	5689.3	3.23
Sandy Point	41 39 41.12	71 24 16.16	353 40 17	Calf Pasture	173 40 29	3808.0	4164.3	2.37
			258 00 04	Warwick light	78 01 19	2692.8	2944.8	1.67
Green's Point	41 41 01.44	71 24 22.20	304 39 40	Warwick light	124 41 00	3372.1	3687.6	2.10
			356 46 28	Sandy Point	176 46 32	2481.6	2713.8	1.54
North Popasquash	41 40 52.43	71 17 51.23	75 21 47	Warwick light	255 18 47	6480.1	7086.4	4.03
			31 44 17	Pine Hill	211 42 42	6316.2	6907.2	3.92
Nayat light of 1863	41 43 28.48	71 20 00.84	26 53 05	Warwick light	206 51 31	7235.6	7912.6	4.50
			328 05 26	North Popasquash	148 06 52	5670.4	6200.9	3.52
Connimicut	41 42 59.52	71 21 08.41	310 40 43	North Popasquash	130 42 54	6012.8	6575.5	3.74
			240 13 11	Nayat light of 1863	60 13 56	1799.3	1967.7	1.12
Babcock	41 42 42.19	71 18 03.75	97 09 20	Connimicut	277 07 17	4301.6	4704.0	2.67
			355 06 51	North Popasquash	175 06 59	3398.4	3716.4	2.11
Rumstick	41 42 21.88	71 17 46.71	123 32 53	Nayat light of 1863	303 31 24	3719.2	4067.2	2.31
			2 10 07	North Popasquash	182 10 04	2761.4	3019.7	1.72
Hall	41 43 09.90	71 16 44.52	64 59 14	Babcock	244 58 21	2020.9	2210.0	1.26
			19 59 30	North Popasquash	199 58 45	4512.5	4934.7	2.80
Stevens	41 44 42.00	71 22 35.03	327 39 16	Connimicut	147 40 14	3741.7	4091.8	2.32
			271 04 06	Bullock's Neck, 1863	91 05 00	1869.4	2044.3	1.16
Sable Point	41 46 00.26	71 21 45.10	25 32 14	Stevens	205 31 41	2675.5	2925.8	1.66
			343 42 38	Bullock's Neck, 1863	163 42 59	2551.7	2790.5	1.59

GEOGRAPHICAL POSITIONS—Continued.

Section I.—Narragansett Bay, R. I.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Pawtuxet	41 45 54.68	71 22 52.92	349 33 19	Stevens	169 33 31	2280.0	2493.3	1.42
			314 55 52	Bullock's Neck, 1863	134 56 57	3224.0	3525.7	2.00
Kettle Point	41 47 44.23	71 22 19.99	12 40 59	Pawtuxet	192 40 37	3463.9	3788.0	2.15
			345 53 57	Sable Point	165 54 21	3307.1	3616.6	2.05
North end of barn, on Hope Island.	41 36 07.76	71 21 39.45	131 05 52	Calf Pasture	311 04 20	4256.2	4654.5	2.65
			7 54 51	Conanicut North	187 54 38	3274.1	3580.5	2.03
White House, north chimney	41 40 43.94	71 26 43.40	299 37 33	Sandy Point	119 39 11	3918.3	4285.0	2.43
			260 35 54	Green's Point	80 37 28	3309.7	3619.4	2.06
Yellow barn, cupola	41 40 59.62	71 26 52.61	303 46 25	Sandy Point	123 48 09	4354.5	4761.9	2.71
			269 03 48	Green's Point	89 05 28	3479.3	3804.9	2.16
Bullock's Neck, 1863	41 44 40.86	71 21 14.12	357 34 58	Connimicut	177 35 02	3129.1	3421.9	1.94
			322 49 03	Nayat light of 1863	142 49 52	2802.3	3064.5	1.74
Providence, High Street Church spire.	41 49 03.64	71 24 55.22	319 53 51	Fort Independence	139 54 59	3683.1	4027.7	2.29
			304 20 49	Kettle Point	124 22 32	4340.3	4746.4	2.70
Vitriol Works, chimney	41 49 47.47	71 25 00.88	329 01 13	Fort Independence	149 02 25	4863.0	5318.0	3.02
			315 39 41	Kettle Point	135 41 28	5314.3	5811.6	3.30
Pawtuxet, Church spire, 1863	41 45 57.00	71 23 09.50	267 02 11	Sable Point	87 03 08	1951.5	2134.1	1.21
			178 40 23	Fort Independence	358 40 21	2940.6	3215.8	1.83
Buttonwood House	41 41 16.97	71 25 37.30	327 35 19	Sandy Point	147 36 13	3502.0	3829.7	2.18
			297 58 29	Warwick light	118 00 39	5107.7	5585.6	3.17
Vue de l'Eau Hotel	41 47 13.71	71 21 44.04	105 42 22	Fort Independence	285 41 23	2120.3	2318.7	1.32
			33 07 42	Pawtuxet	213 06 56	2910.8	3183.2	1.81
Stargut Island, northeast gable of house.	41 47 07.89	71 22 34.87	197 02 21	Kettle Point	17 02 31	1172.7	1282.5	0.73
			130 58 24	Fort Independence	310 57 59	1149.0	1256.5	0.71
Fox Point Rolling-mill, chimney.	41 48 57.60	71 23 34.77	348 55 10	Fort Independence	168 55 25	2681.4	2932.3	1.67
			322 39 53	Kettle Point	142 40 43	2846.6	3112.9	1.77
Rocky Point Hotel, chimney	41 41 19.74	71 21 35.51	279 12 30	North Popasquash	99 14 59	5254.7	5746.3	3.26
			208 50 50	Nayat light of 1863	28 51 53	4534.2	4958.5	2.82
Yellow House, west chimney	41 43 39.71	71 19 02.16	75 40 39	Nayat light of 1863	255 40 00	1399.7	1530.7	0.87
			342 22 03	North Popasquash	162 22 50	5414.7	5921.3	3.36
Warren, Methodist church spire	41 43 46.61	71 16 41.65	83 05 27	Nayat light of 1863	263 03 14	4637.0	5070.9	2.88
			16 40 17	North Popasquash	196 39 31	5609.0	6133.8	3.48
Warren Beacon, (Allen's Rock)	41 42 46.57	71 17 16.18	83 00 07	Babcock	262 59 35	1107.7	1211.3	0.69
			12 57 58	North Popasquash	192 57 35	3612.7	3950.8	2.24
Barn, white cupola	41 42 20.49	71 16 34.36	171 14 37	Hall	351 14 30	1541.9	1686.2	0.96
			107 57 38	Babcock	287 56 38	2171.7	2374.9	1.35
Brown's red house, cupola	41 45 02.32	71 23 03.18	284 42 33	Bullock's Neck, 1863	104 43 46	2604.7	2848.4	1.62
			225 15 01	Sable Point	45 15 53	2538.9	2776.4	1.58
Quonsett, 1868	41 35 14.82	71 24 02.25	299 23 12	Conanicut North	119 24 34	3279.2	3586.1	2.04
			226 13 18	Pine Hill	46 15 49	7290.6	7972.8	4.53
Hull	41 32 12.32	71 22 15.28	156 14 54	Quonsett, 1868	336 13 43	6151.0	6726.6	3.82
			194 38 30	Pine Hill	14 39 50	11030.6	12062.8	6.85
Reynolds	41 33 43.33	71 26 31.18	230 42 00	Quonsett, 1868	50 43 39	4456.9	4873.9	2.77
			259 05 38	Conanicut North	79 08 39	6423.1	7024.1	3.99
Barber's Heights	41 31 42.63	71 25 07.17	152 24 30	Reynolds	332 23 34	4202.1	4595.3	2.61
			192 56 06	Quonsett, 1868	12 56 49	6715.7	7344.1	4.17
Sherman's house, chimney	41 33 45.20	71 22 03.29	135 06 15	Quonsett, 1868	315 04 56	3903.3	4268.5	2.43
			5 32 40	Hull	185 32 32	2878.3	3147.6	1.79
School-house, chimney	41 32 16.01	71 22 12.36	75 45 30	Barber's Heights	255 43 34	4180.7	4571.9	2.60
			114 12 41	Reynolds	294 09 49	6574.8	7189.9	4.08
Barn, cupola, (Conanicut)	41 32 06.46	71 22 16.01	79 30 49	Barber's Heights	259 28 56	4034.5	4412.0	2.51
			116 49 57	Reynolds	296 47 08	6625.7	7245.6	4.12
Potter's wind-mill, shaft	41 30 54.02	71 22 07.72	109 49 39	Barber's Heights	289 47 40	4421.8	4835.6	2.75
			175 50 46	Hull	355 50 41	2420.5	2646.9	1.50
Dutch Island, flag-staff	41 30 17.05	71 23 43.82	143 47 59	Barber's Heights	323 47 04	3271.6	3577.7	2.03
			177 20 21	Quonsett, 1868	357 20 09	9195.4	10055.8	5.71
Wickford Academy	41 34 04.47	71 27 00.29	242 13 38	Quonsett, 1868	62 15 36	4659.4	5095.4	2.90
			313 59 27	Reynolds	133 59 46	938.2	1026.0	0.58
Dutch Island light	41 29 45.99	71 23 56.25	155 26 27	Barber's Heights	335 25 40	3955.1	4325.2	2.46
			179 12 54	Quonsett, 1868	359 12 50	10143.6	11092.7	6.30

GEOGRAPHICAL POSITIONS—Continued.

Section I.—Narragansett Bay, R. I.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Narragansett Church	41 29 31.37	71 25 12.54	188 44 04	Quonsett, 1868	8 44 51	10719.1	11722.1	6.66
			219 36 03	Hull	39 38 00	6445.3	7048.4	4.00
Wickford, Baptist church	41 34 17.37	71 26 44.42	244 43 45	Quonsett, 1868	64 45 33	4153.6	4542.2	2.58
			334 43 28	Barber's Heights	154 44 32	5278.8	5772.7	3.28
Fox Island, chimney	41 33 12.77	71 24 45.66	194 56 54	Quonsett, 1868	14 57 23	3896.8	4261.4	2.42
			298 08 17	Hull	118 09 57	3952.6	4322.4	2.46
Tefft's barn, cupola	41 31 30.67	71 25 14.02	193 30 55	Quonsett, 1868	13 31 43	7111.3	7776.7	4.42
			203 17 04	Barber's Heights	23 17 09	401.8	439.4	0.25
Hamilton's mill	41 32 55.28	71 25 56.15	220 11 31	Pine Hill	40 15 18	12241.4	13386.8	7.61
			211 29 40	Quonsett, 1868	31 30 56	5048.7	5521.1	3.14
Sanford's mill, chimney	41 33 03.70	71 26 32.56	284 51 55	Hull	104 54 46	6169.5	6746.8	3.83
			321 38 04	Barber's Heights	141 39 01	3189.1	3487.6	1.98
Fish-house, chimney	41 34 39.76	71 26 30.91	274 46 15	Conanicut North	94 49 16	6322.9	6914.6	3.93
			307 29 30	Hull	127 32 20	7467.4	8166.1	4.64
Smith's barn, cupola	41 35 57.85	71 25 02.08	330 56 32	Hull	150 58 23	7958.7	8703.4	4.95
			304 40 11	Conanicut North	124 42 13	5159.6	5642.4	3.21
Vaughn's house, cupola	41 34 23.41	71 27 24.77	251 18 10	Quonsett, 1868	71 20 24	4951.4	5414.7	3.08
			314 52 16	Reynolds	134 52 52	1752.2	1916.1	1.09
Green's barn, cupola	41 33 40.13	71 26 10.33	225 26 01	Quonsett, 1868	45 27 26	4163.5	4553.0	2.59
			257 17 26	Conanicut North	77 20 13	5970.3	6528.9	3.71
Browning's house, chimney	41 31 58.59	71 25 28.63	198 17 11	Quonsett, 1868	18 18 08	6375.6	6972.1	3.96
			314 41 48	Barber's Heights	134 42 02	699.9	765.4	0.43
Signal flag	41 35 29.94	71 25 21.25	293 52 37	Conanicut North	113 54 51	5125.9	5605.6	3.18
			357 20 06	Barber's Heights	177 20 15	7019.8	7676.6	4.36
Poor-house, northeast gable	41 35 19.76	71 24 29.81	283 27 05	Quonsett, 1868	103 27 23	656.2	717.6	0.41
			331 39 41	Hull	151 41 10	6568.6	7183.2	4.08
QUAKER	41 34 55.14	71 14 57.37						
MIANTONOMY	41 30 34.80	71 18 16.44	118 32 44	Hull	298 30 06	6300.4	6889.9	3.91
DUMPLIN	41 28 43.42	71 21 46.89	234 50 39	Miantonomy	54 52 58	5969.0	6527.5	3.71
			174 10 29	Hull	354 10 10	6476.6	7082.6	4.02
McSparran, 1869	41 29 15.57	71 27 03.43	235 51 05	Hull	55 54 16	8069.9	8825.0	5.01
			284 36 00	Dumplin	104 39 30	7587.4	8297.4	4.71
Meeting-house, 1869	41 26 40.97	71 28 12.67	195 44 47	McSparran, 1869	15 45 33	5916.7	6470.3	3.68
			247 04 48	Dumplin	67 09 03	9715.6	10624.7	6.04
Sugarloaf	41 26 02.78	71 30 19.15	213 26 12	McSparran, 1869	33 28 22	8237.5	9008.3	5.12
			248 07 18	Meeting-house, 1869	68 08 42	3163.5	3459.5	1.97
Telegraph Hill, 1869	41 27 15.03	71 19 50.70	157 53 01	Hull	337 51 25	8901.1	9734.0	5.53
			202 38 26	Miantonomy	22 39 28	5674.4	6205.3	3.53
Paradise Rock	41 30 03.24	71 15 24.53	55 23 48	Telegraph Hill, 1869	235 20 52	7502.4	8204.4	4.66
			103 44 23	Miantonomy	283 42 29	4103.9	4487.9	2.55
Prudence, 1869	41 36 19.99	71 18 20.82	299 02 29	Quaker	119 04 44	5389.8	5894.1	3.35
			359 27 42	Miantonomy	179 27 45	10648.0	11644.3	6.62
Church's Point, 1869	41 30 07.64	71 12 00.00	155 09 04	Quaker	335 07 06	9775.2	10689.9	6.07
			189 03 46	Windmill	9 04 06	4488.3	4908.3	2.79
Gibbs No. 2	41 29 37.28	71 16 07.42	231 09 06	Paradise Rock	51 09 34	1276.6	1396.0	0.79
			56 15 22	Telegraph Hill, 1869	236 12 54	6229.9	6812.8	3.87
Ocean House	41 28 50.99	71 18 09.66	177 10 09	Miantonomy	357 10 05	3205.9	3505.9	1.99
			49 03 14	Telegraph Hill, 1869	229 02 07	3103.9	3394.4	1.93
Fort Adams, flag-staff, 1869	41 28 43.61	71 19 59.33	153 55 17	Hull	333 53 47	7168.3	7839.1	4.45
			89 53 15	Dumplin	269 52 04	2496.0	2729.6	1.55
Andrew Potter's house, chimney	41 30 27.66	71 21 17.66	157 32 09	Hull	337 31 31	3494.5	3821.5	2.17
			338 05 24	Telegraph Hill, 1869	158 06 22	5407.8	5913.8	3.36
Beaver Tail Neck, west gable of barn.	41 28 32.90	71 23 07.45	112 18 08	McSparran, 1869	292 15 32	5915.5	6469.0	3.68
			190 07 33	Hull	10 08 08	6876.8	7520.2	4.27
Coal Mine, middle chimney	41 37 07.65	71 16 05.87	43 14 23	Hull	223 10 18	12497.6	13667.0	7.77
			64 48 07	Prudence, 1869	244 46 37	3453.7	3776.8	2.15
Portsmouth Grove, flag-staff	41 35 10.76	71 16 52.77	53 39 21	Hull	233 35 47	9279.7	10148.0	5.77
			136 18 59	Prudence, 1869	316 18 01	2952.1	3228.3	1.83
Ben Hall's house, west chimney	41 35 06.02	71 16 20.31	129 17 40	Prudence, 1869	309 16 20	3604.4	3941.6	2.24
			279 54 44	Quaker	99 55 39	1950.4	2132.9	1.21

GEOGRAPHICAL POSITIONS—Continued.

Section I.—Narragansett Bay, R. I.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
North Windmill	41 35 13.79	71 14 55.00	5 20 26	Quaker	185 20 24	577.2	631.2	0.35
			267 44 20	Wing	87 47 03	5693.9	6226.7	3.54
Anderson's barn, cupola	41 33 39.11	71 17 02.52	69 56 16	Hull	249 42 49	7725.0	8447.9	4.80
			159 55 55	Prudence, 1869	339 55 03	5283.7	5778.0	3.28
South Portsmouth, church tower	41 33 27.96	71 15 00.93	289 36 02	Windmill	109 38 22	5201.9	5688.7	3.23
			181 45 21	Quaker	1 45 23	2690.1	2941.8	1.67
Episcopal church tower	41 32 48.05	71 15 21.36	83 29 08	Hull	263 24 34	9655.5	10558.9	6.00
			275 28 05	Windmill	95 30 39	5398.5	5903.6	3.36
Gould Island, cupola of barn	41 31 59.78	71 20 20.12	98 15 48	Hull	278 14 32	2697.1	2949.5	1.68
			312 26 27	Miantonomy	132 27 48	3884.4	4247.9	2.41
Fair-grounds, tower	41 31 14.35	71 16 06.87	101 51 45	Hull	281 47 41	8725.0	9541.4	5.42
			335 53 41	Paradise Rock	155 54 09	2403.2	2628.1	1.49
Beaver Tail light, 1869	41 26 55.67	71 23 38.68	217 56 31	Dumplin	37 57 45	4216.3	4610.8	2.62
			137 49 48	McSparran, 1869	317 47 32	7073.6	7735.4	4.40
Watson's house, chimney	41 28 20.16	71 25 44.80	48 17 34	Meeting-house, 1869	228 15 56	4597.4	5027.6	2.86
			145 19 04	McSparran, 1869	325 18 12	3204.6	3504.4	1.99
Dr. Potter's house, chimney	41 26 58.74	71 26 09.58	242 03 10	Dumplin	62 06 04	6897.5	7542.9	4.29
			79 09 02	Meeting-house, 1869	259 07 41	2908.9	3181.0	1.81
Dr. Wharton's house, east chimney.	41 24 54.46	71 26 55.62	151 26 37	Meeting-house, 1869	331 25 46	3741.1	4091.1	2.32
			178 50 37	McSparran, 1869	358 50 32	8982.1	9822.6	5.58
Hazard's Castle	41 24 52.92	71 27 07.51	226 15 44	Dumplin	46 19 16	10293.0	11256.1	6.40
			115 51 48	Sugarloaf	295 49 41	4943.8	5406.4	3.07
Tefft's house, chimney	41 27 59.15	71 27 17.04	28 10 05	Meeting-house, 1869	208 09 28	2734.8	2990.6	1.70
			185 29 30	McSparran, 1869	5 29 39	3298.5	3607.1	2.05
Wakefield, white spire	41 26 22.06	71 29 50.19	211 37 46	McSparran, 1869	31 39 36	7374.5	8064.5	4.58
			48 30 11	Sugarloaf	228 29 52	897.5	981.5	0.56
Wakefield, gray spire	41 26 23.39	71 29 30.08	253 11 27	Meeting-house, 1869	73 12 18	1877.0	2052.7	1.17
			60 50 22	Sugarloaf	240 49 49	1304.4	1426.4	0.81
Kingston, spire	41 28 46.71	71 31 12.59	252 32 04	McSparran, 1869	72 34 49	6057.6	6624.4	3.76
			312 52 39	Meeting-house, 1869	132 54 38	5698.6	6231.8	3.54
Peirce's barn, cupola	41 25 31.88	71 28 29.86	110 35 49	Sugarloaf	290 34 37	2710.3	2963.9	1.68
			190 36 15	Meeting-house, 1869	10 36 26	2168.3	2371.2	1.35
Rose Island, flag-staff	41 29 45.27	71 20 13.38	48 41 53	Dumplin	228 40 51	2888.6	3158.9	1.79
			240 34 51	Miantonomy	60 36 08	3111.3	3402.4	1.93
Belmont's house, cupola	41 27 49.91	71 18 01.55	221 30 35	Paradise Rock	41 32 19	5493.1	6007.1	3.41
			107 33 00	Dumplin	287 30 31	5483.5	5996.6	3.41
Bronson's house, flag-staff	41 27 49.52	71 21 07.34	274 26 39	Telegraph Hill, 1869	94 27 30	1783.6	1950.5	1.11
			151 06 12	Dumplin	331 05 46	1900.4	2078.2	1.18
Balch's house, north chimney	41 28 58.24	71 15 59.99	67 08 42	Telegraph Hill, 1869	247 06 09	5809.4	6353.0	3.61
			202 16 52	Paradise Rock	22 17 15	2166.7	2369.4	1.35
Sand Point light	41 36 26.65	71 18 09.37	302 24 16	Quaker	122 26 23	5266.5	5759.2	3.27
			0 52 13	Miantonomy	180 52 08	10853.5	11869.0	6.74
Slate Hill, flag-staff	41 32 19.89	71 15 35.44	49 03 04	Miantonomy	229 01 17	4944.3	5406.9	3.07
			266 26 38	Windmill	86 29 21	5711.5	6245.9	3.55
Four Corners, belfry	41 34 29.29	71 11 01.44	189 55 33	Wing	9 55 41	1619.7	1771.2	1.01
			10 07 15	Windmill	190 06 56	3696.7	4042.6	2.30
Widow Potter's barn, cupola	41 33 15.74	71 11 56.06	126 08 53	Quaker	306 06 53	5200.0	5686.6	3.23
			335 48 36	Windmill	155 48 54	1502.5	1643.0	0.93
New York Club, flagstaff	41 26 58.50	71 11 38.10	97 12 07	Telegraph Hill, 1869	277 06 41	11521.1	12599.1	7.16
			137 20 43	Paradise Rock	317 18 13	7750.9	8476.2	4.82
Fogland Point, north gable of house.	41 33 40.66	71 12 50.65	128 04 13	Quaker	308 02 49	3727.4	4076.2	2.32
			318 40 26	Windmill	138 41 20	2848.2	3114.7	1.77
Griswold's barn, south cupola	41 32 56.45	71 13 59.80	224 41 05	Wing	44 43 11	6273.7	6860.7	3.90
			282 31 48	Windmill	102 33 28	3569.2	3903.2	2.22
Portsmouth, belfry	41 36 11.13	71 14 32.68	286 37 09	Wing	106 39 37	5398.9	5904.0	3.35
			327 56 12	Windmill	147 58 14	7999.3	8747.8	4.97
Lawton's house, north flagstaff	41 37 31.16	71 12 27.95	330 22 01	Wing	150 23 06	4619.6	5051.9	2.87
			351 39 33	Windmill	171 40 12	9347.6	10222.2	[illegible]
Howland's barn, cupola	41 32 01.90	71 11 25.06	137 23 35	Quaker	317 21 14	7263.1	7943.0	4.51
			173 32 17	Windmill	353 32 14	913.7	998.7	0.57

GEOGRAPHICAL POSITIONS—Continued.

Section II.—Connecticut River, Connecticut.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
NICKERSON	41 23 51.55	72 19 19.01	....		....	....	....	....
MOUNT PARNASSUS	41 28 01.34	72 24 20.03	317 46 03	Nickerson	137 49 22	10402.4	11375.7	6.46
Long Hill	41 26 43.22	72 30 04.50	253 11 30	Mt. Parnassus	73 15 18	8349.3	9130.6	5.19
			289 24 04	Nickerson	109 31 11	15895.4	17382.7	9.88
Emmons	41 32 04.12	72 31 47.18	305 47 48	Mt. Parnassus	125 52 44	12791.3	13988.2	7.95
			346 27 47	Long Hill	166 28 55	10181.6	11134.2	6.33
Moodus	41 31 11.23	72 27 12.15	325 42 36	Mt. Parnassus	145 44 30	7088.6	7751.9	4.40
			104 22 46	Emmons	284 19 44	6581.0	7196.8	4.09
Thayer	41 31 53.62	72 34 46.74	325 36 57	Long Hill	145 40 04	11598.9	12684.2	7.21
			265 32 09	Emmons	85 34 08	4175.0	4565.7	2.59
Jones	41 27 57.06	72 27 12.00	179 57 50	Moodus	359 57 50	5989.5	6549.9	3.72
			359 11 58	Holt	179 12 00	4258.4	4656.9	2.65
Shaler	41 27 45.66	72 28 40.45	331 34 58	Holt	151 35 58	4441.2	4856.7	2.76
			265 24 01	Mt. Parnassus	85 26 53	6062.0	6629.2	3.77
Smith	41 30 29.80	72 00 34.86	254 46 23	Moodus	74 48 37	4870.9	5326.7	3.03
			302 46 56	Bald Hill	122 50 46	9618.7	10518.7	5.98
Paphro	41 28 38.17	72 31 09.90	193 16 26	Smith	13 16 49	3538.6	3869.7	2.20
			172 15 18	Emmons	352 14 53	6412.2	7012.2	3.98
Salmon	41 28 17.06	72 27 40.04	285 29 26	Bald Hill	105 31 21	4181.9	4573.2	2.60
			55 21 29	Shaler	235 20 49	1704.0	1863.5	1.06
Brainerd	41 29 16.23	72 31 15.49	202 32 42	Smith	22 33 09	2457.3	2687.2	1.53
			171 55 38	Emmons	351 55 17	5231.2	5720.7	3.25
Haddam Neck	41 28 53.07	72 29 07.93	342 57 41	Shaler	162 58 00	2174.8	2378.2	1.35
			302 42 13	Jones	122 43 29	3197.0	3496.2	1.99
Selden Neck	41 30 47.92	72 31 09.61	2 45 30	Brainerd	182 45 26	2831.7	3096.7	1.76
			111 57 09	Thayer	291 54 45	5426.2	5933.9	3.37
Arnold's quarry	41 28 23.79	72 30 08.08	135 04 22	Thayer	315 01 17	9145.7	10001.4	5.68
			107 10 25	Paphro	287 09 43	1501.4	1641.8	0.93
Swan's Hill	41 30 06.76	72 33 11.47	208 21 01	Emmons	28 21 57	4114.1	4499.1	2.56
			300 05 05	Brainerd	120 06 22	3108.8	3399.7	1.93
Hudson River, N. Y., from New Baltimore to Albany.								
TRAVER	42 30 12.85	73 45 20.06	....	....	....	....	....	....
MULL	42 30 01.56	73 46 48.40	260 11 59	Traver	80 12 59	2046.4	2237.9	1.27
Ten Eyck, 1856	42 28 46.24	73 45 30.35	185 01 33	Traver	5 01 40	2682.1	2933.1	1.67
			142 31 36	Mull	322 30 43	2928.3	3202.3	1.82
Coeyman, 1856	42 28 20.99	73 47 07.64	250 39 53	Ten Eyck, 1856	70 40 59	2354.7	2575.0	1.46
			188 03 45	Mull	8 03 58	3134.0	3427.3	1.95
Vanderzee	42 30 40.72	73 46 33.84	15 22 09	Mull	195 21 59	1253.1	1370.4	0.78
			297 02 54	Traver	117 03 44	1891.2	2068.1	1.18
Castleton	42 31 47.68	73 45 01.91	45 27 08	Vanderzee	225 26 06	2944.4	3219.9	1.83
			8 03 32	Traver	188 03 20	2955.2	3231.7	1.84
Osterhout	42 31 33.09	73 46 26.11	6 13 44	Vanderzee	186 13 39	1625.3	1777.4	1.01
			256 48 25	Castleton	76 49 22	1973.6	2168.2	1.23
Cedar Hill	42 32 49.76	73 45 19.69	32 39 12	Osterhout	212 38 27	2809.4	3072.3	1.75
			348 02 19	Castleton	168 02 31	1957.9	2141.1	1.22
Campbell	42 32 16.12	73 44 40.93	139 34 16	Cedar Hill	319 33 50	1363.6	1491.1	0.85
			61 03 47	Osterhout	241 02 36	2742.8	2999.5	1.70
South base	42 30 52.70	73 45 29.04	200 03 04	Castleton	20 03 22	1805.9	1974.9	1.12
			133 44 28	Osterhout	313 43 49	1802.7	1971.4	1.12
North base	42 31 42.27	73 45 10.59	80 40 35	Osterhout	260 39 44	1746.5	1909.9	1.09
			15 23 49	South base	195 23 37	1586.4	1734.8	0.99
Winnie's Point	42 33 16.40	73 45 06.06	342 52 15	Campbell	162 52 32	1946.3	2128.4	1.21
			268 00 12	Thorp	88 01 06	1820.4	1990.7	1.13
Van Wie	42 33 51.91	73 44 58.42	9 02 49	Winnie's Point	189 02 44	1109.6	1213.4	0.69
			302 06 55	Thorp	122 07 44	1942.0	2123.7	1.21
Miller	42 34 03.51	73 43 59.55	75 05 06	Van Wie	255 04 26	1389.5	1519.5	0.86
			347 44 48	Thorp	167 44 57	1422.8	1556.0	0.88

GEOGRAPHICAL POSITIONS—Continued.

Section II.—Hudson River, N. Y., from New Baltimore to Albany.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Welch	42 34 36.31	73 45 04.92	353 49 32	Van Wie	173 49 36	1377.7	1506.6	0.86
			304 09 51	Miller	124 10 35	1801.6	1970.1	1.12
Van Rensselaer	42 35 43.32	73 44 11.42	30 32 36	Welch	210 32 00	2400.5	2625.1	1.49
			354 58 36	Miller	174 58 44	3091.3	3380.5	1.92
Wendell	42 35 58.00	73 45 44.88	340 07 32	Welch	160 07 59	2680.3	2931.1	1.67
			282 00 03	Van Rensselaer	102 01 06	2178.1	2381.9	1.35
Papscanee	42 36 46.57	73 45 04.08	31 49 31	Wendell	211 49 03	1763.6	1928.6	1.10
			328 24 20	Van Rensselaer	148 24 56	2291.2	2505.6	1.42
Corning	42 36 52.35	73 45 55.70	351 37 56	Wendell	171 38 03	1694.7	1853.2	1.05
			278 36 25	Papscanee	98 37 00	1189.8	1301.1	0.74
Mole	42 37 27.80	73 45 17.66	38 23 45	Corning	218 23 19	1395.7	1526.3	0.87
			346 19 28	Papscanee	166 19 37	1309.2	1431.7	0.81
Crouts	42 37 28.10	73 44 15.13	89 38 36	Mole	269 37 54	1424.8	1558.1	0.89
			41 02 54	Papscanee	221 02 21	1698.6	1857.5	1.06
Westerlo	42 38 05.00	73 45 02.99	16 14 28	Mole	196 14 18	1195.3	1307.1	0.74
			316 14 07	Crouts	136 14 39	1576.4	1723.9	0.98
Beacon East	42 35 07.64	73 44 52.79	15 55 12	Welch	195 55 04	1006.1	1100.3	0.63
			220 33 55	Van Rensselaer	40 34 23	1449.7	1585.3	0.90
Old Wharf	42 31 39.23	73 45 42.86	254 24 34	Castleton	74 25 02	970.1	1060.9	0.60
			79 08 08	Osterhout	259 07 39	1005.1	1099.2	0.62
Borden	42 29 48.49	73 46 42.42	319 23 57	Ten Eyck, 1856	139 24 46	2529.0	2765.6	1.57
			248 12 27	Traver	68 13 23	2024.8	2214.2	1.26
Island	42 31 14.11	73 45 42.61	120 31 58	Osterhout	300 31 29	1152.7	1260.6	0.72
			221 52 46	Castleton	41 53 14	1391.1	1521.3	0.86
Talmadge	42 30 56.11	73 45 59.80	218 15 29	North base	38 16 02	1813.6	1983.3	1.13
			219 42 23	Castleton	39 43 02	2068.1	2261.6	1.29
Clapper	42 30 59.22	73 45 30.69	199 02 54	North base	19 03 08	1405.2	1536.7	0.87
			203 42 40	Castleton	23 42 59	1633.2	1786.0	1.02
Elm Tree	42 30 48.42	73 45 46.04	205 57 35	North base	25 57 59	1847.8	2020.7	1.15
			208 50 33	Castleton	28 51 03	2087.3	2282.6	1.30
Broom	42 31 18.56	73 45 55.11	122 21 37	Osterhout	302 21 16	837.6	916.0	0.52
			338 27 46	Traver	158 28 10	2179.7	2383.6	1.35
Shad Island	42 30 35.31	73 46 18.99	218 13 19	Castleton	38 14 11	2842.5	3108.4	1.77
			341 43 55	Ten Eyck, 1856	161 44 28	3543.6	3875.1	2.20
Herrick	42 30 16.90	73 46 05.28	138 25 24	Vanderzee	318 25 05	982.5	1074.4	0.61
			64 19 24	Mull	244 18 55	1092.1	1194.3	0.68
McAllister	42 29 54.39	73 46 17.89	202 30 41	Herrick	22 30 50	751.9	822.3	0.47
			107 37 57	Mull	287 37 36	730.7	799.1	0.45
Slate	42 30 22.63	73 46 28.93	217 06 45	Castleton	37 07 44	3291.0	3598.9	2.04
			335 46 30	Ten Eyck, 1856	155 47 10	3260.7	3565.8	2.03
Mull Plaat	42 29 20.32	73 46 39.17	170 36 30	Mull	350 36 24	1289.7	1410.4	0.80
			303 46 28	Ten Eyck, 1856	123 47 15	1890.8	2067.7	1.17
Bowlder	42 29 04.72	73 46 58.98	187 51 09	Mull	7 51 16	1770.3	1935.9	1.10
			227 03 09	Traver	47 04 16	3085.2	3373.9	1.92
Mull Cove	42 29 19.87	73 46 57.44	297 32 28	Ten Eyck, 1856	117 33 27	2243.1	2453.0	1.39
			233 40 19	Traver	53 41 25	2759.4	3017.6	1.71
Flat Point	42 28 16.91	73 46 50.33	209 56 42	Traver	29 57 43	4128.3	4514.6	2.57
			243 37 44	Ten Eyck, 1856	63 38 38	2038.6	2229.3	1.27
Crann	42 27 18.34	73 46 57.59	278 04 39	Reed	98 05 27	1628.4	1780.8	1.01
			216 17 53	Ten Eyck, 1856	36 18 52	3365.6	3680.5	2.09
Barren Island, south, 1856	42 27 49.50	73 46 49.53	225 55 20	Ten Eyck, 1856	45 56 13	2517.1	2752.7	1.56
			10 51 01	Crann	190 50 56	978.8	1070.4	0.61
Vyde Hook	42 27 40.36	73 46 25.26	116 57 57	Barren Isl'd, south, 1856	296 57 41	621.9	680.1	0.39
			316 06 51	Reed	136 07 17	1260.2	1378.1	0.78
Red Pole, west	42 25 52.82	73 46 43.64	177 51 33	Barren Isl'd, south, 1856	357 51 29	3602.3	3939.3	2.24
			173 06 37	Crann	353 06 28	2657.7	2906.4	1.65
Coeyman's Beacon	42 28 31.34	73 46 45.00	211 45 51	Traver	31 46 48	3683.7	4028.3	2.29
			178 24 36	Mull	358 24 34	2784.8	3045.3	1.73
New Baltimore beacon	42 27 02.99	73 46 43.04	259 10 38	Reed	79 11 16	1302.9	1424.8	0.81
			207 31 17	Ten Eyck, 1856	27 32 06	3592.4	3928.5	2.23

GEOGRAPHICAL POSITIONS—Continued.

Section II.—Hudson River, N. Y., from New Baltimore to Albany.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
New Baltimore signal	42 26 22.68	73 46 49.89	223 58 43	Reed	43 59 25	2068.4	2261.9	1.29
			180 10 36	Barren Isl'd, south, 1856.	0 10 36	2678.6	2929.2	1.66
Willow Point	42 32 55.60	73 44 57.02	246 23 31	Thorp	66 24 19	1760.1	1924.8	1.09
			178 56 44	Van Wie	358 56 43	1737.6	1900.2	1.08
Staats	42 34 13.70	73 44 41.25	30 13 42	Van Wie	210 13 30	778.0	850.7	0.48
			323 40 52	Thorp	143 41 29	2115.6	2313.5	1.31
Smith's Island, north	42 33 28.74	73 44 42.53	54 39 37	Winnie's Point	234 39 21	658.2	719.8	0.41
			153 07 13	Van Wie	333 07 02	801.5	876.5	0.50
Smith's Island, south	42 32 36.87	73 44 59.71	8 22 55	North base	188 22 48	1702.9	1862.3	1.06
			1 53 53	Castleton	181 53 52	1518.7	1660.8	0.94
Richardson	42 34 19.14	73 45 02.20	354 08 45	Van Wie	174 08 48	844.5	923.5	0.52
			289 21 37	Staats	109 21 51	506.4	553.8	0.31
Pixitaway	42 33 48.92	73 44 35.05	99 50 13	Van Wie	279 49 57	540.8	591.4	0.34
			35 11 00	Winnie's Point	215 10 39	1227.6	1342.5	0.76
Boutell	42 32 59.17	73 44 33.78	160 57 10	Van Wie	340 56 53	1721.6	1882.6	1.07
			125 49 25	Winnie's Point	305 49 03	908.2	993.2	0.56
Sill	42 32 11.73	73 45 30.46	333 29 07	North base	153 29 20	1015.8	1110.8	0.63
			318 42 51	Castleton	138 43 10	787.4	1079.8	0.61
Cow Island beacon	42 32 14.40	73 45 01.72	56 30 37	Osterhout	236 29 40	2309.3	2525.4	1.44
			82 50 06	Sill	262 49 47	661.0	722.9	0.41
Scammerhann	42 31 47.29	73 45 28.06	268 51 01	Castleton	88 51 19	596.8	652.6	0.37
			175 50 29	Sill	355 50 27	755.9	826.7	0.47
Tide gauge	42 31 53.06	73 45 07.77	138 02 56	Sill	318 02 41	774.5	846.9	0.48
			68 58 42	Scammerhann	248 58 28	496.0	542.4	0.31
Lower Red	42 31 29.58	73 45 48.50	338 40 52	South base	158 41 05	1221.4	1335.7	0.76
			242 16 45	Castleton	62 17 16	1201.0	1313.4	0.75
Upper Red	42 31 54.30	73 45 36.02	284 42 31	Castleton	104 42 54	804.7	880.0	0.50
			193 16 19	Sill	13 16 23	552.4	604.1	0.34
Camp	42 32 38.41	73 44 43.01	52 45 04	Sill	232 44 32	1360.0	1487.2	0.85
			112 42 16	Cedar Hill	292 41 51	907.0	991.9	0.56
Thorp 2	42 33 34.81	73 44 20.33	208 09 33	Miller	28 09 47	1004.3	1098.3	0.62
			61 26 23	Winnie's Point	241 25 52	1188.0	1299.1	0.74
Van Wie's wharf	42 34 44.63	73 44 59.20	313 00 13	Miller	133 00 53	1860.2	2034.2	1.16
			211 01 50	Van Rensselaer	31 02 22	2113.0	2310.7	1.31
Marsh	42 34 46.45	73 44 42.95	202 16 52	Van Rensselaer	22 17 13	1896.1	2073.5	1.18
			147 24 34	Wendell	327 23 53	2620.5	2865.7	1.63
Bear Point	42 33 41.79	73 45 02.46	244 57 41	Miller	64 58 23	1583.5	1731.6	0.98
			5 59 41	Winnie's Point	185 59 39	987.8	861.5	0.49
Dow	42 37 22.68	73 44 56.77	55 07 44	Corning	235 07 04	1636.7	1789.8	1.02
			108 21 40	Mole	288 21 26	501.5	548.4	0.31
Rock	42 35 09.73	73 45 13.95	233 58 34	Van Rensselaer	53 59 16	1762.4	1927.3	1.10
			154 40 14	Wendell	334 39 53	1648.0	1802.2	1.02
Cooper	42 35 18.43	73 45 00.38	235 28 08	Van Rensselaer	55 28 41	1354.9	1481.7	0.84
			140 17 30	Wendell	320 17 00	1998.5	2185.5	1.24
Wand	42 34 53.81	73 45 04.60	218 26 30	Van Rensselaer	38 27 06	1950.2	2132.7	1.21
			155 08 00	Wendell	335 07 33	2183.0	2387.3	1.36
Wall	42 35 30.01	73 45 20.77	341 44 28	Wand	161 44 39	1176.1	1286.2	0.73
			147 31 50	Wendell	327 31 34	1023.7	1119.4	0.64
Stone	42 35 52.61	73 45 26.83	344 23 40	Wand	164 23 55	1883.4	2059.6	1.17
			279 27 43	Van Rensselaer	99 28 34	1742.7	1905.8	1.08
Brown	42 35 54.39	73 45 10.91	355 36 14	Wand	175 36 18	1874.6	2050.0	1.16
			284 08 23	Van Rensselaer	104 09 03	1398.5	1529.4	0.87
Hall	42 36 13.29	73 45 14.33	141 58 00	Corning	321 57 32	1530.0	1673.2	0.95
			55 53 26	Wendell	235 53 05	841.0	919.7	0.52
Pond	42 36 29.04	73 45 29.00	226 23 35	Papscanee	46 23 52	784.3	857.7	0.49
			308 34 37	Van Rensselaer	128 35 30	2262.1	2473.8	1.41
Beacon Island	42 36 00.05	73 45 28.82	201 26 31	Papscanee	21 26 48	1542.4	1686.7	0.96
			344 53 00	Wand	164 53 16	2116.7	2314.7	1.32
Blunt	42 34 17.29	73 43 50.90	109 10 41	Welch	289 09 51	1786.9	1954.1	1.11
			63 03 22	Van Wie	243 02 36	1727.4	1889.0	1.07

GEOGRAPHICAL POSITIONS—Continued.

Section II—Hudson River, N. Y., from New Batimore to Albany.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Henry	42 37 05.27	73 45 16.62	65 52 41	Corning	245 52 15	975.6	1066.9	0.61
			333 38 03	Papscanee	153 38 12	643.9	704.2	0.40
Todd	42 37 45.34	73 44 43.30	143 31 32	Westerlo	323 31 19	754.4	825.0	0.47
			55 21 21	Mole	235 20 58	951.5	1040.5	0.59
Greenbush Station	42 38 04.48	73 44 40.66	91 47 26	Westerlo	271 47 11	508.9	556.5	0.32
			5 48 58	Todd	185 48 56	593.8	649.4	0.37
West	42 37 59.85	73 44 59.89	313 50 57	Crouts	133 51 27	1414.3	1546.6	0.88
			319 50 02	Todd	139 50 13	586.0	640.9	0.36
Small Island	42 37 42.52	73 45 07.82	357 10 18	Papscanee	177 10 21	1728.1	1889.8	1.07
			290 19 43	Crouts	110 20 19	1280.2	1400.0	0.80
Bogart Island	42 37 11.08	73 45 15.64	57 39 57	Corning	237 39 30	1080.4	1181.5	0.67
			190 24 36	Small Island	10 24 41	986.1	1078.4	0.61
Old railroad depot, east gable end.	42 38 09.24	73 44 54.33	20 25 51	Small Island	200 25 42	880.0	962.3	0.55
			4 58 29	Papscanee	184 58 23	2560.2	2799.7	1.59

Section III.—Potomac River.

GEORGE NO. 1	38 06 07.97	76 27 55.18	....	....	....	....	....	....
LYNCH'S POINT	38 02 41.63	76 30 47.36	213 23 43	George No. 1	33 25 29	7620.6	8333.7	4.74
Mundy's Point Poplar	38 01 13.61	76 32 22.47	220 30 42	Lynch's Point	40 31 40	3569.7	3903.7	2.22
			167 35 16	Horn Point	347 35 11	853.1	932.9	0.53
Piney Point, light-house signal	38 08 03.39	76 31 29.27	3 54 36	Sandy Point	183 54 24	6776.7	7410.8	4.21
			304 17 34	George No. 1	124 19 46	6312.8	6903.5	3.92
Tower Hill	38 12 19.18	76 34 26.09	24 56 34	Ragged Point	204 55 20	6972.3	7624.7	4.33
			331 21 41	Piney Pt. L. H. signal	151 23 31	8983.7	9824.3	5.58
Old Cole	38 09 09.64	76 37 35.08	282 53 01	Piney Pt. L. H. signal	102 56 47	9137.8	9992.8	5.68
			218 11 20	Tower Hill	38 13 17	7436.3	8132.1	4.62
New Cole	38 09 09.58	76 37 34.83	282 52 51	Piney Pt. L. H. signal	102 56 37	9131.3	9985.7	5.67
			218 08 34	Tower Hill	38 10 30	7434.1	8129.7	4.62
Cupola	38 13 28.79	76 38 39.14	289 12 21	Tower Hill	109 14 57	6519.0	7128.9	4.05
			348 55 05	New Cole	168 55 45	8142.6	8904.5	5.06
Blue Sow	38 13 59.80	76 42 00.42	285 38 39	Tower Hill	105 43 20	11478.0	12551.9	7.13
			324 08 26	New Cole	144 11 10	11036.7	12069.4	6.86
Copsico	38 09 28.25	76 41 13.49	276 09 21	New Cole	96 11 36	5353.9	5854.9	3.33
			172 14 15	Blue Sow	352 13 46	8449.6	9240.2	5.25
Blakiston's light-house pole	38 12 22.94	76 44 24.00	229 26 53	Blue Sow	49 28 22	4595.2	5025.2	2.86
			319 15 54	Copsico	139 17 51	7106.4	7771.3	4.42
Blakiston's light-house, center	38 12 23.00	76 44 24.00	....	....	....	....	....	....
Hollis	38 09 37.23	76 44 29.33	181 27 22	Blakiston's L. H. pole	1 27 25	5110.7	5588.9	3.18
			273 18 32	Copsico	93 20 33	4775.3	5222.1	2.97
Pawpaw	38 15 45.42	76 39 03.71	51 19 05	Blakiston's L. H. pole	231 15 46	9981.6	10915.5	6.20
			351 55 19	Cupola	171 55 34	4254.7	4652.8	2.64
Nun's Oak	38 14 16.79	76 39 29.91	63 53 32	Blakiston's L. H. pole	243 50 30	7967.8	8713.3	4.95
			320 09 07	Cupola	140 09 39	1927.9	2108.3	1.20
Lover's Point	38 15 29.84	76 38 25.71	297 28 19	Pawpaw	297 27 55	1040.6	1138.0	0.65
			34 44 07	Nun's Oak	214 43 27	2740.1	2996.5	1.70
Mulberry Point	38 16 06.11	76 38 20.22	58 53 18	Pawpaw	238 52 51	1234.5	1350.0	0.77
			6 49 03	Lover's Point	186 49 00	1125.9	1231.3	0.70
Society Hill	38 15 33.19	76 39 37.67	245 27 20	Pawpaw	65 27 41	907.6	992.5	0.56
			273 21 58	Lover's Point	93 22 43	1752.0	1915.9	1.09
St. Patrick	38 14 09.88	76 43 57.80	10 56 27	Blakiston's L. H. pole	190 56 11	3358.2	3672.5	2.09
			276 11 45	Blue Sow	96 12 58	2871.2	3139.8	1.78
Long Point	38 14 23.57	76 43 02.08	28 11 06	Blakiston's L. H. pole	208 10 15	4219.1	4613.9	2.62
			72 42 32	St. Patrick	252 41 58	1419.0	1551.7	0.88
Bluff Woods	38 15 13.50	76 42 58.[illegible]	36 10 40	St. Patrick	216 10 03	2429.8	2657.1	1.51
			2 57 16	Long Point	182 57 14	1541.7	1686.0	0.96

GEOGRAPHICAL POSITIONS—Continued.

Section III.—Potomac River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Chapel Point	38 15 26.50	76 42 08.26	34 00 07	Long Point	213 59 34	2340.3	2559.2	1.45
			71 56 57	Bluff Woods	251 56 26	1292.7	1413.7	0.80
Shipping Point	38 15 53.89	76 42 31.49	28 04 36	Bluff Woods	208 04 19	1411.4	1543.4	0.88
			326 14 06	Chapel Point	146 14 20	1016.1	1111.2	0.63
Howard's Point	38 16 12.22	76 42 17.75	350 42 03	Chapel Point	170 42 09	1428.6	1562.3	0.89
			30 34 38	Shipping Point	210 34 29	656.3	717.7	0.41
Rocky Point	38 16 51.52	76 42 16.71	11 26 07	Shipping Point	191 25 58	1812.6	1982.2	1.13
			1 12 24	Howard's Point	181 12 23	1211.9	1325.3	0.75
Old Windmill Point	38 17 10.02	76 42 42.18	353 41 13	Shipping Point	173 41 20	2361.3	2582.2	1.47
			312 39 42	Rocky Point	132 39 58	841.6	920.3	0.52
Guess Point	38 17 41.44	76 42 37.37	341 56 09	Rocky Point	161 56 22	1619.0	1770.4	1.01
			6 52 58	Old Windmill Point	186 52 55	975.7	1067.0	0.61
Long Bar	38 18 10.49	76 43 05.22	343 16 57	Old Windmill Point	163 17 11	1946.4	2128.5	1.21
			322 55 20	Guess Point	142 55 37	1122.5	1227.5	0.70
Potomac	38 08 53.86	76 36 26.66	139 18 03	Blue Sow	319 14 37	12446.8	13611.4	7.73
			204 51 43	Tower Hill	24 52 58	6976.8	7629.6	4.34
Lower Machadoc	38 09 09.25	76 37 33 73	144 06 15	Blue Sow	324 03 30	11061.3	12096.3	6.87
			217 56 06	Tower Hill	37 58 02	7425.5	8120.3	4.61
Upper Machadoc	38 08 47.90	76 39 36.21	159 57 52	Blue Sow	339 56 23	10236.7	11194.5	6.36
			229 10 40	Tower Hill	49 13 52	9969.5	10902.3	6.19
Glebe Creek	38 08 00.12	76 38 50.17	142 43 45	Upper Machadoc	322 43 16	1851.1	2024.3	1.15
			41 07 09	Lower Machadoc	41 07 56	2829.5	3094.3	1.76
Bluff Point	38 08 04.55	76 37 55.37	84 09 06	Glebe Creek	264 08 32	1341.4	1466.9	0.83
			118 33 47	Upper Machadoc	298 32 45	2795.3	3056.9	1.74
Small white house, east chimney	38 07 28.27	76 37 39.62	119 45 29	Glebe Creek	299 44 45	1978.7	2163.8	1.23
			130 51 27	Upper Machadoc	310 50 15	3753.0	4104.2	2.33
White two-story house, east chimney.	38 07 10.26	76 37 47.74	135 19 05	Glebe Creek	315 18 27	2161.9	2364.2	1.34
			173 40 01	Bluff Point	353 39 56	1684.1	1841.7	1.05
Herring Pond	38 09 28.90	76 40 59.91	241 15 19	Tower Hill	61 19 23	10927.3	11949.8	6.79
			170 00 30	Blue Sow	349 59 52	8480.8	9274.4	5.27
Nomini Hill	38 10 03.52	76 47 04.49	225 24 50	Blue Sow	45 27 58	10382.3	11353.8	6.45
			276 49 34	Herring Pond	96 53 19	8938.2	9774.6	5.55
Chantilly	38 09 37.28	76 44 29.36	204 06 16	Blue Sow	24 07 48	8867.9	9697.6	5.51
			272 52 55	Herring Pond	92 55 04	5104.8	5582.4	3.17
Currioman	38 09 30.91	76 41 50.59	92 55 26	Chantilly	272 53 48	3869.7	4231.8	2.40
			97 31 29	Nomini Hill	277 28 15	7706.7	8427.8	4.79
Ellis	38 13 28.23	76 45 31.93	259 15 54	Blue Sow	79 18 05	5234.9	5724.8	3.25
			19 38 45	Nomini Hill	199 37 48	6701.1	7328.1	4.16
St. Margaret Island	38 14 58.24	76 48 23.20	303 39 42	Ellis	123 41 28	5004.5	5472.7	3.11
			348 05 41	Nomini Hill	168 06 30	9285.9	10154.8	5.77
Bluff	38 15 15.47	76 50 17.56	280 48 15	St. Margaret Island	100 49 26	2830.6	3095.5	1.76
			333 57 22	Nomini Hill	153 59 22	10703.1	11704.6	6.65
Pope's Creek	38 11 56.20	76 54 39.35	238 26 20	St. Margaret Island	58 30 13	10732.5	11736.7	6.67
			225 59 59	Bluff	46 02 41	8847.3	9675.2	5.50
Piney Point light	38 08 03.41	76 31 29.22	151 22 59	Tower Hill	331 21 10	8983.7	9824.3	5.58
			102 08 47	Potomac	282 05 44	7407.5	8100.6	4.60
Fisher's Point	38 04 23.97	76 31 48.56	140 52 32	Potomac	320 49 40	10729.5	11733.5	6.67
			183 59 11	Piney Point light	3 59 23	6781.7	7416.3	4.21
St. Mary	38 06 06.85	76 28 13.99	58 46 44	Fisher's Point	238 44 32	6115.4	6687.6	3.80
			127 05 53	Piney Point light	307 03 53	5960.3	6518.0	3.70
Yeocomico	38 02 39.22	76 30 46.71	154 58 30	Fisher's Point	334 57 52	3564.3	3897.8	2.21
			210 09 47	St. Mary	30 11 21	7404.5	8097.3	4.60
Lower Potomac	38 00 39.12	76 27 20.21	136 40 33	Fisher's Point	316 37 48	9532.4	10424.3	5.92
			126 20 32	Yeocomico	306 18 25	6250.2	6835.0	3.88
Three Pines	38 03 10.28	76 21 00.52	63 18 50	Lower Potomac	243 14 56	10365.2	11335.1	6.44
			117 17 55	St. Mary	297 13 28	11883.8	12995.8	7.38
Cubitt's Creek	37 56 57.03	76 20 49.22	125 41 51	Lower Potomac	305 37 50	11743.3	12842.1	7.30
			178 37 42	Three Pines	358 37 35	11510.3	12587.3	7.15
Ragged Point Tree	38 08 54.04	76 36 26.91	139 18 18	Blue Sow	319 14 52	12438.5	13602.4	7.73
			106 05 29	Lower Machadoc	286 04 48	1692.9	1851.3	1.05
Lonesome house, south chimney	38 08 35.75	76 40 11.07	230 36 19	Tower Hill	50 39 52	10859.6	11875.7	6.75
			246 10 30	Upper Machadoc	66 10 52	927.5	1014.3	0.58

GEOGRAPHICAL POSITIONS—Continued.

Section III.—Potomac River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Chantilly House, south chimney	38 09 08.70	76 45 28.01	249 54 48	Tower Hill	70 01 37	17145.4	18749.7	10.65
			262 36 34	Currioman	82 38 48	5336.7	5836.0	3.32
Clinton Dean's house, southeast chimney.	38 08 58.62	76 31 57.11	88 43 37	Potomac	268 41 43	6564.1	7178.3	4.08
			92 19 13	Lower Machadoc	272 15 45	8201.7	8969.2	5.10
Hollis' shed, chimney	38 09 41.98	76 44 35.40	168 51 04	Ellis	348 50 29	7109.6	7774.8	4.42
			205 21 47	Blue Sow	25 23 23	8797.7	9620.9	5.47
Cliff Flag	38 10 09.36	76 51 12.58	204 48 46	St. Margaret Island	24 50 31	9812.9	10731.1	6.10
			188 04 05	Bluff	8 04 39	9531.4	10423.2	5.92
Colton's house, southeast chimney.	38 13 16.98	76 44 50.01	252 14 03	Blue Sow	72 15 48	4330.4	4735.6	2.69
			28 45 37	Nomini Hill	208 44 14	6803.1	7439.7	4.23
Huggins' Point, flag	38 13 52.30	76 40 58.07	51 40 43	Nomini Hill	231 36 56	11367.7	12431.3	7.06
			98 41 15	Blue Sow	278 40 36	1533.9	1677.5	0.95
Robert Coomb's house, south chimney.	38 13 59.95	76 39 56.54	10 27 34	Herring Pond	190 26 55	8497.6	9292.7	5.28
			55 02 26	Nomini Hill	234 58 01	12709.6	13898.8	7.90
Abel's house, south apex	38 13 26.03	76 37 10.12	37 25 41	Herring Pond	217 23 19	9205.6	10066.9	5.72
			66 42 10	Nomini Hill	246 36 03	15750.2	17223.9	9.79
Thomas Hobbs' quarters, chimney.	38 12 22.33	76 34 31.09	23 38 46	Potomac	203 37 35	7016.1	7672.6	4.36
			60 33 49	Herring Pond	240 29 49	10867.6	11884.5	6.75
Long house, south chimney	38 11 54.94	76 33 43.82	47 37 27	Lower Machadoc	227 35 05	7574.3	8283.0	4.71
			80 04 10	Nomini Hill	259 55 55	19784.4	21635.6	12.29
Fishing Point, flag	38 08 18.20	76 42 42.91	133 15 40	Chantilly	313 14 34	3557.9	3890.8	2.21
			209 36 21	Currioman	29 36 53	2578.1	2819.4	1.60
Island House, chimney	38 14 58.58	76 48 19.82	100 19 27	Bluff	280 18 14	2909.3	3181.5	1.81
			348 36 20	Nomini Hill	168 37 07	9279.4	10147.7	5.77
St. Catharine, tree	38 14 15.80	76 47 40.25	67 08 45	Pope's Creek	247 04 26	11064.7	12100.0	6.87
			115 41 03	Bluff	295 40 26	4244.0	4641.1	2.64
Washington's birth place, (Wakefield,) east chimney.	38 12 15.69	76 56 15.56	237 29 09	Bluff	57 32 51	10320.5	11286.1	6.41
			246 23 28	St. Margaret Island	66 28 20	12533.5	13706.2	7.79
Mattox Creek House, southeast chimney.	38 12 49.61	76 57 28.11	246 43 10	Bluff	66 47 36	11394.7	12460.9	7.08
			253 17 33	St. Margaret Island	73 23 10	13832.0	15126.3	8.59
Daniel Blakiston's, southwest chimney.	38 13 47.01	76 46 29.19	128 23 50	St. Margaret Island	308 22 39	3536.5	3867.4	2.20
			116 10 38	Bluff	296 08 17	6186.2	6765.1	3.84
Fisherman's shed, west apex	38 10 14.28	66 52 07.65	211 55 53	St. Margaret Island	31 58 12	10317.6	11283.0	6.41
			238 07 23	Ellis	58 11 28	11333.6	12394.0	7.04
Lone locust tree	38 11 56.40	76 54 43.59	238 45 06	St. Margaret Island	58 49 01	10817.0	11829.2	6.72
			226 29 22	Bluff	46 32 07	8917.7	9752.1	5.54
Hawk's Nest	38 03 12.61	76 21 02.87	62 48 56	Lower Potomac	242 45 04	10346.5	11314.6	6.43
			358 21 05	Cubitt's Creek	178 21 13	11583.8	12667.7	7.20
Hull Creek House, north chimney.	37 57 23.22	76 23 08.68	134 33 39	Lower Potomac	314 31 04	8610.5	9416.1	5.35
			196 16 38	Three Pines	16 17 57	11147.1	12190.2	6.93
West Pine	38 00 41.68	76 27 23.46	136 41 53	Fisher's Point	316 39 10	9420.5	10301.9	5.85
			173 00 01	St. Mary	352 59 30	10100.2	11045.3	6.28
Coan River	37 59 24.67	76 26 22.83	148 37 42	Lower Potomac	328 37 07	2688.4	2940.0	1.67
			228 28 02	Three Pines	48 31 21	10497.0	11479.2	6.52
Kingscote	37 59 44.75	76 27 24.13	183 16 01	Lower Potomac	3 16 03	1678.7	1835.8	1.04
			292 29 19	Coan River	112 29 57	1618.7	1770.1	1.01
John Bitzel's, northeast chimney.	37 59 44.77	76 27 29.56	236 13 55	Three Pines	56 17 55	11408.3	12475.8	7.09
			290 50 24	Coan River	110 51 05	1742.1	1905.1	1.08
Sanford House, northeast chimney.	38 09 52.82	76 46 40.48	217 48 27	East Nomini	37 48 33	413.6	452.3	0.26
			215 38 56	Blakiston's light-house pole.	35 40 20	5696.4	6229.4	3.54
Yeocomico River.								
Windmill Point	38 01 36.78	76 30 38.35	173 57 26	Yeocomico	353 57 20	1935.6	2116.7	1.20
			202 53 50	St. Mary	22 55 19	9038.9	9884.6	5.62
Old windmill	38 01 21.69	76 30 12.76	255 59 07	Three Pines	76 04 47	13875.8	15174.1	8.62
			160 53 28	Yeocomico	340 53 07	2529.6	2766.3	1.57
Bain Point	38 01 31.09	76 31 52.50	217 22 06	Yeocomico	37 22 47	2642.8	2890.1	1.64
			264 27 19	Windmill Point	84 28 05	1816.7	1986.7	1.13
Kinsale Point	38 01 40.75	76 32 30.43	272 33 08	Windmill Point	92 34 17	2735.8	2991.7	1.70
			287 49 46	Bain Point	107 50 09	971.6	1062.5	0.60

GEOGRAPHICAL POSITIONS—Continued.

Section III.—Yeocomico River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Cherry tree	38 01 32.12	76 31 48.46	216 02 44	Yeocomico	36 03 22	2558.5	2797.9	1.59
			265 11 27	Windmill Point	85 12 10	1715.7	1876.2	1.07
Lyle's house, east chimney	38 01 13.93	76 32 22.50	166 50 29	Kinsale Point	346 50 24	849.1	928.6	0.53
			234 07 08	Bain Point	54 07 26	903.1	987.6	0.56
Jos. Hudson's, west chimney	38 01 25.15	76 33 49.16	255 55 54	Kinsale Point	75 56 43	1979.4	2164.6	1.23
			266 18 07	Bain Point	86 19 19	2851.0	3117.8	1.77
Ebbitt's house, south chimney	38 02 16.83	76 32 55.15	290 17 58	Windmill Point	110 19 22	3556.9	3889.7	2.21
			312 42 03	Bain Point	132 42 42	2078.9	2273.4	1.29
Breton's Bay.								
Forbes	38 13 30.52	76 38 39.32	76 05 04	Blakiston's light, center	256 01 31	8638.3	9446.6	5.37
			171 53 31	Pawpaw	351 53 16	4200.7	4593.8	2.61
Breton	38 14 39.43	76 39 59.60	317 24 44	Forbes	137 25 34	2885.2	3155.2	1.79
			213 44 35	Pawpaw	33 45 10	2446.5	2675.4	1.52
W. Goughs	38 15 29.84	76 38 25.67	55 46 04	Breton	235 45 06	2762.2	3020.6	1.72
			117 27 11	Pawpaw	297 26 47	1041.4	1138.8	0.65
Reeds Point	38 15 29.96	76 40 08.23	270 04 33	W. Goughs	90 05 37	2493.1	2726.4	1.55
			352 19 45	Breton	172 19 50	1572.0	1719.1	0.98
South	38 14 48.36	76 40 18.28	190 46 54	Reed's Point	10 47 00	1305.5	1427.6	0.81
			244 57 07	W. Goughs	64 58 17	3021.4	3304.1	1.88
Greenwell	38 15 51.25	76 38 05.65	36 24 02	W. Goughs	216 23 50	820.2	896.9	0.51
			82 43 52	Pawpaw	262 43 16	1422.3	1555.4	0.88
Gurten	38 16 06.53	76 38 19.93	323 37 50	Greenwell	143 37 59	585.0	639.8	0.36
			58 32 01	Pawpaw	238 31 34	1247.3	1364.0	0.78
Ginies Point	38 16 28.02	76 37 24.50	41 25 39	Greenwell	221 25 14	1512.6	1654.1	0.94
			63 48 53	Gurten	243 48 19	1501.3	1641.7	0.93
Buzzard Point	38 16 42.88	76 37 39.16	322 07 14	Ginies Point	142 07 23	580.4	634.7	0.36
			22 01 38	Greenwell	202 01 22	1717.1	1877.8	1.07
S. Foxwell, center chimney	38 16 57.72	76 37 33.05	347 12 38	Ginies Point	167 12 43	938.7	1026.5	0.58
			17 59 38	Buzzard Point	197 59 34	480.9	525.9	0.30
Hickory tree	38 16 43.22	76 37 40.27	320 42 39	Ginies Point	140 42 49	605.5	662.1	0.38
			21 03 30	Greenwell	201 03 14	1717.0	1877.7	1.07
J. Gurten's house, center chimney.	38 16 06.73	76 38 20.30	244 10 14	Ginies Point	64 10 49	1506.7	1647.6	0.94
			323 17 35	Greenwell	143 17 44	595.5	651.2	0.37
Hawk's Nest	38 14 38.84	76 40 12.61	183 52 00	Reeds Point	3 52 03	1579.6	1727.4	0.98
			238 49 34	W. Goughs	58 50 40	3038.3	3322.6	1.89
H. J. Kaywood	38 14 19.26	76 41 43.57	226 45 04	Reeds Point	46 46 03	3181.9	3479.7	1.98
			245 38 48	W. Goughs	65 40 50	5280.5	5774.5	3.28
C. Thompson, south chimney	38 15 34.27	76 40 52.86	276 59 16	Reeds Point	96 59 44	1093.1	1195.4	0.68
			329 17 13	South	149 17 34	1646.4	1800.5	1.02
Windmill	38 15 43.53	76 41 22.78	275 35 07	W. Goughs	95 36 57	4325.9	4730.7	2.69
			317 19 12	South	137 19 52	2313.5	2529.9	1.44
Wicomico River.								
Wicomico	38 15 30.72	76 50 02.37	292 32 49	St. Margaret Island	112 33 50	2610.7	2855.0	1.62
			336 46 11	Nomini Hill	156 48 01	10976.5	12003.6	6.82
Hammett	38 16 04.83	76 48 13.70	6 24 54	St. Margaret Island	186 24 48	2066.1	2259.4	1.28
			68 17 55	Wicomico	248 16 48	2843.1	3109.1	1.77
Lancaster	38 16 21.58	76 49 42.12	323 14 48	St. Margaret Island	143 15 37	3206.6	3506.6	1.99
			283 30 04	Hammett	103 31 01	2210.0	2416.8	1.37
Charleston Creek	38 17 17.48	76 50 05.87	309 23 51	Hammett	129 25 01	3528.2	3858.4	2.19
			341 28 38	Lancaster	161 28 53	1817.7	1987.8	1.13
Pond Point	38 18 01.04	76 49 12.53	13 11 45	Lancaster	193 11 27	3149.7	3444.4	1.96
			338 14 30	Hammett	158 15 06	3857.5	4218.4	2.40
Cob Neck	38 18 54.07	76 50 47.16	305 24 46	Pond Point	125 25 45	2820.7	3084.7	1.75
			341 22 53	Charleston Creek	161 23 19	3142.1	3436.1	1.95
Mills Point	38 20 09.18	76 50 13.80	339 21 12	Pond Point	159 21 50	4221.5	4616.5	2.62
			19 17 03	Cob Neck	199 16 42	2453.2	2682.7	1.52
Bowman's Creek	38 20 14.17	76 51 50.62	273 44 09	Mills Point	93 45 09	2356.2	2576.7	1.46
			328 01 21	Cob Neck	148 02 00	2911.1	3183.5	1.81
Wicomico farm	38 20 38.79	76 51 31.20	341 40 03	Cob Neck	161 40 30	3401.1	3719.3	2.11
			31 51 48	Bowman's Creek	211 51 36	893.8	977.5	0.56
Chaptico	38 21 04.05	76 49 69.20	11 50 34	Mills Point	191 50 25	1728.2	1889.9	1.07
			70 47 34	Wicomico Farm	250 46 37	2365.4	2586.7	1.47

GEOGRAPHICAL POSITIONS—Continued.

Section III.—Wicomico River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Stoddard	38 21 28.31	76 51 04.62	295 13 03	Chaptico	115 13 44	1755.6	1919.8	1.09
			333 10 09	Mills Point	153 10 41	2733.8	2989.6	1.70
Lancaster wharf, northeast post	38 16 19.33	76 49 43.86	321 53 12	St. Margaret Island	141 54 02	3177.3	3474.6	1.97
			281 31 20	Hammett	101 32 16	2236.5	2445.8	1.39
E. A. Wells, southwest chimney	38 14 58.83	76 47 48.47	106 49 01	Wicomico	286 47 38	3400.4	3718.5	2.11
			132 43 51	Lancaster	312 42 41	3760.3	4112.1	2.34
Plowden's house, southwest chimney.	38 17 45.70	76 47 17.73	23 37 46	Hammett	203 37 11	3394.1	3711.7	2.11
			53 32 33	Lancaster	233 31 03	4363.0	4771.3	2.71
Plowden's store, flag-staff	38 16 55.34	76 48 04.17	103 00 23	Charleston Creek	282 59 08	3035.2	3319.2	1.89
			8 27 44	Hammett	188 27 38	1573.9	1721.2	0.98
White Pine Island, flag in tree	38 17 03.22	76 48 51.93	41 46 50	Lancaster	221 46 21	1721.2	1882.2	1.07
			104 19 08	Charleston Creek	284 18 24	1779.1	1945.6	1.11
Clavoe's house, west chimney	38 19 02.76	76 49 20.87	121 11 52	Bowman's Creek	301 10 19	4251.5	4649.3	2.64
			18 37 04	Charleston Creek	198 36 36	3424.9	3745.4	2.13
Spaulding's cupola	38 18 30.25	76 49 04.31	106 23 20	Cob Neck	286 22 16	2603.9	2847.6	1.62
			33 41 49	Charleston Creek	213 41 11	2696.3	2948.6	1.68
Bluff Tree	38 17 57.25	76 50 36.63	187 45 41	Mills Point	7 45 55	4105.1	4489.2	2.55
			266 42 50	Pond Point	86 43 42	2046.7	2238.2	1.27
J. W. Bourrough's east chimney	38 20 48.80	76 51 26.07	304 50 25	Mills Point	124 51 10	2131.8	2331.3	1.32
			257 26 04	Chaptico	77 26 58	2160.9	2363.1	1.34
Range Oak	38 19 40.65	76 49 47.13	45 25 57	Cob Neck	225 25 20	2046.4	2237.9	1.27
			143 38 08	Mills Point	323 37 51	1092.4	1194.6	0.68
Bluff House, chimney	38 21 52.97	76 49 56.63	7 25 36	Mills Point	187 25 25	3227.0	3529.0	2.00
			2 22 09	Chaptico	182 22 07	1509.7	1650.9	0.94
Bashwood's quarter's, north chimney.	38 20 44.41	76 49 18.34	86 56 32	Wicomico Farm	266 55 10	3230.3	3532.5	2.01
			121 24 30	Chaptico	301 24 04	1162.1	1270.8	0.72
Duncan Turner's house, west chimney.	38 20 03.35	76 49 51.92	96 36 51	Bowman's Creek	276 35 37	2901.9	3173.4	1.80
			146 01 55	Stoddard	326 01 10	3158.8	3454.3	1.96
St. Clement's Bay.								
St. Clement	38 13 37.04	76 44 23.79	258 36 12	Blue Sow	78 37 41	3556.4	3889.2	2.21
			0 07 58	Blakiston's light, center	180 07 58	2282.8	2496.4	1.42
Mattingly	38 14 18.3[illegible]	76 42 56.19	30 58 58	Blakiston's light, center	210 58 04	4149.6	4537.9	2.58
			59 06 19	St. Clement	239 05 25	2482.4	2714.7	1.54
Canoe Neck	38 15 13.69	76 42 58.60	36 12 40	St. Patrick	216 12 03	2439.1	2667.4	1.52
			34 48 48	St. Clement	214 47 55	3629.0	3968.5	2.25
Newtown	38 15 27.87	76 42 05.04	30 08 46	Mattingly	210 08 14	2476.9	2708.6	1.51
			71 26 54	Canoe Neck	251 26 21	1373.5	1502.0	0.85
Commercial Point	38 15 53.93	76 42 31.89	320 54 20	Newtown	140 54 37	1035.2	1132.1	0.64
			27 37 38	Canoe Neck	207 37 21	1400.1	1531.1	0.87
Lynn Oaks	38 16 18.67	76 42 14.67	28 03 49	Canoe Neck	208 03 22	2270.0	2482.4	1.41
			28 45 33	Commercial Point	208 45 23	870.1	951.5	0.54
Cedar Point	38 17 10.86	76 42 43.88	336 11 19	Lynn Oaks	156 11 37	1758.6	1923.1	1.09
			352 59 41	Commercial Point	172 59 48	3289.5	3597.3	2.04
Hazel	38 16 49.96	76 42 17.80	11 12 53	Commercial Point	191 12 44	1761.0	1925.8	1.09
			355 29 09	Lynn Oaks	175 29 11	967.6	1058.1	0.60
Riker's Creek	38 17 46.73	76 42 33.40	350 29 03	Lynn Oaks	170 29 14	2752.7	3010.3	1.71
			347 47 04	Hazel	167 47 14	1790.7	1958.3	1.11
Benjamin Swan's north chimney	38 17 44.06	76 43 11.80	321 48 21	Hazel	141 48 54	2122.4	2321.0	1.32
			326 28 18	Cedar Point	146 28 35	1228.1	1343.1	0.76
Jeremiah Hubbard's northeast chimney.	38 18 07.95	76 43 18.19	334 39 44	Cedar Point	154 40 05	1947.3	2129.5	1.21
			335 22 45	Lynn Oaks	155 23 24	3706.1	4052.9	2.30
Mathew Stone's west chimney	38 18 15.65	76 42 45.06	342 22 04	Riker's Creek	162 22 11	935.7	1023.2	0.58
			345 55 23	Hazel	165 55 40	2723.5	2978.3	1.69
Mill House, west chimney	38 17 29.93	76 42 04.89	14 18 38	Hazel	194 18 30	1272.0	1391.0	0.79
			12 30 15	Commercial Point	192 29 58	3031.3	3314.9	1.88
Lynn Howard's northwest chimney.	38 16 18.70	76 42 12.23	171 59 46	Hazel	351 59 43	973.1	1064.2	0.60
			353 38 23	Newtown	173 38 27	1577.0	1724.6	0.98
Thomas McWilliams' north chimney.	38 16 18.83	76 42 51.76	220 41 58	Hazel	40 42 19	1266.0	1384.5	0.79
			324 08 19	Newtown	144 08 48	1938.4	2119.8	1.20

GEOGRAPHICAL POSITIONS—Continued.

Section III.—St. Clement's Bay.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
James McWilliams' south chimney.	38 16 41.83	76 42 47.26	250 41 22	Hazel	70 41 40	758.4	829.4	0.47
			312 01 58	Lynn Oaks	132 02 18	1066.2	1166.0	0.66
Bluff Wood's house, chimney	38 15 25.87	76 42 52.98	209 45 47	Lynn Oaks	29 46 11	1875.4	2050.9	1.17
			210 38 28	Commercial Point	30 38 41	1005.6	1099.7	0.62
Priest House, southwest chimney.	38 15 15.72	76 41 41.69	88 05 35	Canoe Neck	268 04 47	1871.0	2046.1	1.16
			157 33 20	Lynn Oaks	337 33 00	2099.8	2296.2	1.30
Chapel Oak	38 15 22.81	76 42 03.30	144 04 05	Commercial Point	324 03 47	1184.7	1295.5	0.74
			32 55 34	Mattingly	212 55 01	2366.0	2587.4	1.47
Carberry's house, chimney	38 16 01.94	76 41 51.12	17 51 31	Newtown	197 51 22	1103.6	1206.8	0.69
			76 00 46	Commercial Point	256 00 21	1021.4	1116.9	0.63
Piazza House, northwest chimney.	38 15 48.49	76 41 47.57	58 10 15	Canoe Neck	238 09 31	2033.8	2224.1	1.26
			33 39 58	Newtown	213 39 47	764.1	835.6	0.47
St. Clement's Hawk's Nest	38 14 36.15	76 42 19.45	71 17 56	St. Patrick	251 16 55	2526.6	2763.0	1.57
			58 55 49	St. Clement	238 54 32	3530.4	3860.7	2.19
Mattingly House, chimney	38 14 18.72	76 42 51.45	80 24 06	St. Patrick	260 23 25	1637.8	1791.0	1.02
			60 13 29	St. Clement	240 12 32	2587.3	2829.4	1.61
Birch House, north chimney	38 14 25.56	76 43 55.48	6 49 10	St. Patrick	186 49 09	487.6	533.2	0.30
			24 43 13	St. Clement	204 42 55	1646.8	1800.9	1.02
Potomac River.								
PORT TOBACCO BASE, EAST END	38 26 36.80	77 02 07.21						
PORT TOBACCO BASE, WEST END	38 26 51.55	77 02 52.53	292 28 57	East base	112 29 25	1189.0	1300.2	0.74
Chapel Point	38 27 44.30	77 01 33.86	21 14 19	East base	201 13 58	2232.5	2441.4	1.39
			49 33 10	West base	229 32 21	2506.3	2740.8	1.56
Bluff	38 25 31.31	76 59 58.45	122 53 56	East base	302 52 36	3718.7	4066.6	2.31
			150 34 26	Chapel Point	330 33 27	4708.0	5148.5	2.93
Upper Cedar	38 24 23.37	77 05 17.95	254 50 53	Bluff	74 54 11	8028.2	8779.4	4.99
			228 20 12	East base	48 22 10	6190.7	6770.0	3.85
Mathias Point	38 23 42.52	77 03 04.08	194 23 32	East base	14 24 07	5547.4	6066.5	3.45
			233 18 23	Bluff	53 20 18	5615.0	6140.4	3.49
Stewart	38 22 07.17	77 06 06.70	236 25 28	Mathias Point	56 27 22	5318.1	5815.8	3.30
			195 43 51	Upper Cedar	15 44 21	4362.5	4770.7	2.71
Persimmon	38 22 26.49	77 00 28.50	162 46 08	East base	342 45 07	8080.4	8836.4	5.02
			187 17 23	Bluff	7 17 42	5744.5	6282.0	3.57
Lower Cedar	38 20 25.87	76 58 25.70	166 33 57	Bluff	346 32 59	9682.1	10588.1	6.02
			141 17 39	Persimmon	321 16 23	4766.2	5212.2	2.96
Machadoc	38 20 06.10	77 00 36.19	182 28 16	Persimmon	2 28 21	4332.4	4737.8	2.69
			259 06 03	Lower Cedar	79 07 20	3226.8	3528.7	2.00
Rosier	38 16 49.73	76 59 48.46	196 46 50	Lower Cedar	16 47 41	6960.4	7611.6	4.33
			169 09 47	Machadoc	349 09 17	6164.3	6741.1	3.83
Swan Point	38 17 23.94	76 55 10.98	139 52 36	Lower Cedar	319 50 35	7337.1	8023.7	4.56
			81 08 01	Rosier	261 05 09	6825.1	7463.7	4.24
White Point	38 15 34.39	76 57 39.14	152 50 09	Machadoc	332 48 19	9416.8	10297.9	5.85
			226 49 27	Swan Point	46 50 59	4937.3	5399.3	3.07
Lone Locust	38 11 56.26	76 54 39.64	147 01 42	White Point	326 59 51	8017.4	8767.6	4.98
			175 41 35	Swan Point	355 41 16	10131.1	11079.1	6.30
Cob Point	38 15 20.39	76 50 32.97	119 26 10	Swan Point	299 23 18	7756.8	8482.6	4.82
			92 25 23	White Point	272 20 59	10368.7	11338.9	6.44
East Nomini	38 10 03.42	76 46 30.06	106 19 13	Lone Locust	286 14 10	12411.1	13572.4	7.71
			148 51 39	Cob Point	328 49 09	11419.5	12488.0	7.10
Metompkin	38 22 00.46	77 07 57.66	221 19 21	Upper Cedar	41 21 00	5868.0	6417.0	3.65
			265 35 57	Stewart	85 37 06	2701.1	2953.8	1.68
Seminary	38 27 52.25	77 01 07.13	32 03 46	East base	212 03 09	2744.6	3001.4	1.71
			339 01 28	Bluff	159 02 11	4653.6	5089.0	2.89
Deep Point	38 28 30.58	77 01 40.87	10 19 12	East base	190 18 56	3565.6	3899.2	2.22
			325 18 43	Seminary	145 19 04	1437.3	1571.8	0.89
High Field	38 29 24.95	77 01 34.10	347 07 01	Seminary	167 07 18	2932.1	3206.5	1.82
			5 35 47	Deep Point	185 35 43	1684.4	1842.0	1.05
Bird Nest Tree	38 25 33.50	77 03 50.88	232 10 01	East base	52 11 06	3182.6	3480.4	1.98
			270 39 58	Bluff	90 42 23	5637.8	6165.3	3.50

GEOGRAPHICAL POSITIONS—Continued.

Section III.—Potomac River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Portico House, south chimney	38 26 00.97	77 00 02.81	110 07 33 68 32 19	East base Upper Cedar	290 06 16 248 29 04	3212.5 8214.7	3513.1 8983.3	2.00 5.10
Grimes' house, south chimney	38 23 16.22	77 01 24.31	170 27 20 178 23 28	East base Chapel Point	350 26 53 358 23 22	6271.9 8267.3	6858.8 9040.9	3.90 5.14
Brent's house, south chimney	38 28 02.02	77 02 37.53	289 29 47 237 19 47	Chapel Point Deep Point	109 30 27 57 20 22	1637.3 1631.3	1790.5 1783.9	1.02 1.01
Small house, chimney	38 28 03.66	77 02 28.92	234 31 04 207 55 31	Deep Point High Field	54 31 34 27 56 05	1430.2 2836.8	1564.0 3102.2	0.89 1.76
White house on point, chimney	38 29 41.49	77 01 00.89	57 37 41 23 54 10	High Field Deep Point	237 37 20 203 53 45	952.6 2391.5	1041.7 2615.2	0.59 1.49
House on bluff, south chimney	38 30 20.51	77 00 47.38	33 27 38 20 56 03	High Field Deep Point	213 27 09 200 55 30	2053.1 3628.7	2245.2 3968.2	1.28 2.25
Port Tobacco court-house, cupola.	38 30 37.17	77 00 55.80	22 37 16 15 38 06	High Field Deep Point	202 36 52 195 37 38	2412.3 4053.0	2638.0 4432.3	1.50 2.52
Mathias, poplar	38 23 46.47	77 01 59.66	222 17 03 178 00 08	Bluff East base	42 18 18 358 00 03	4369.6 5254.6	4778.5 5746.2	2.72 3.26
Chimney at Mathias Point	38 23 43.38	77 02 00.56	221 40 02 178 16 15	Bluff East base	41 41 18 358 16 11	4455.0 5349.1	4871.9 5849.7	2.77 3.32
Two-story white house, east chimney.	38 22 45.71	77 09 20.62	304 42 24 284 09 05	Metompkin Stewart	124 43 16 104 11 06	2449.5 4854.1	2678.7 5308.3	1.52 3.02
Small white house, south chimney.	38 23 08.40	77 08 31.40	338 38 45 243 46 11	Metompkin Upper Cedar	158 39 06 63 48 11	2248.9 5232.0	2459.3 5721.6	1.40 3.25
House, white chimney with black top.	38 24 30.68	77 06 18.12	27 33 05 356 24 59	Metompkin Stewart	207 32 03 176 25 06	5223.5 4433.3	5712.2 4848.1	3.25 2.75
Naujemoy, poplar	38 23 53.69	77 07 27.80	11 43 50 253 48 03	Metompkin Upper Cedar	191 43 31 73 49 24	3565.2 3280.5	3898.8 3587.4	2.22 2.04
Robert Speaks' house, east chimney.	38 23 26.07	77 07 59.16	359 12 40 245 40 59	Metompkin Upper Cedar	179 12 41 65 42 39	2639.7 4291.7	2886.7 4693.3	1.64 2.67
House at Pope's Creek, south apex.	38 23 52.63	76 59 11.89	34 59 52 3 54 01	Persimmon Rosier	214 59 04 183 53 38	3241.6 13068.5	3544.9 14291.3	2.01 8.12
Mrs. Watson's house, southeast chimney.	38 22 51.22	76 58 50.23	72 16 59 7 14 14	Persimmon Rosier	252 15 58 187 13 38	2503.4 11234.8	2737.6 12286.0	1.56 6.98
Two-story white house, southwest chimney.	38 21 38.32	76 58 29.12	47 20 54 12 13 39	Machadoc Rosier	227 19 35 192 12 50	4195.4 9103.7	4588.0 9955.5	2.61 5.66
Mrs. Harris' house, southeast chimney.	38 20 15.63	76 57 17.52	86 31 53 329 50 43	Machadoc Swan Point	266 29 50 149 52 01	4833.4 6121.2	5285.6 6693.9	3.00 3.80
Red chimney	38 21 31.36	77 00 39.40	313 41 33 301 52 10	Swan Point Lower Cedar	133 44 56 121 53 33	11036.8 3822.7	12069.5 4180.4	6.86 2.37
House near Rosier's Creek, northeast chimney.	38 17 20.35	77 00 28.45	284 17 01 269 08 59	Cob Point Swan Point	104 23 10 89 12 16	14938.0 7714.8	16335.7 8436.6	9.28 4.79
Poplar on Swan Point	38 17 19.68	76 54 24.77	96 40 42 83 19 55	Swan Point Rosier	276 40 13 263 16 35	1130.3 7919.8	1236.0 8660.8	0.70 4.92
Watson's house, south chimney	38 15 43.93	76 57 52.07	273 51 11 231 45 49	Cob Point Swan Point	93 55 43 51 47 29	10698.9 4983.4	11700.0 5449.7	6.65 3.10
Goldman's house, northeast chimney.	38 15 09.76	76 57 27.63	159 45 34 153 23 07	White Point Machadoc	339 45 27 333 21 10	809.3 10220.6	885.1 11177.0	0.50 6.35
Old chimney at Rosier	38 16 50.23	76 59 49.30	307 02 36 169 19 20	Rosier Machadoc	127 02 37 349 18 51	25.5 6145.4	27.9 6720.4	0.02 3.82
Big Oak House, southwest chimney.	38 12 15.64	76 56 15.43	189 21 20 235 36 04	Swan Point Cob Point	9 22 00 55 39 36	9633.4 10089.7	10534.8 11033.8	5.99 6.27
Old windmill	38 16 15.67	76 58 26.96	117 56 13 278 22 30	Rosier Cob Point	297 55 23 98 27 24	2242.2 11646.8	2452.0 12736.6	1.39 7.24
Adams	38 22 28.69	77 09 43.55	277 10 01 288 42 06	Stewart Metompkin	97 12 16 108 43 12	5304.8 2713.5	5801.1 2967.4	3.30 1.69
Wheat	38 20 37.02	77 09 45.64	225 31 49 180 50 37	Metompkin Adams	45 32 56 0 50 38	3672.8 3443.3	4016.5 3765.5	2.28 2.14
Grimes	38 20 22.21	77 11 56.91	261 50 14 219 41 24	Wheat Adams	81 51 35 39 42 47	3220.2 5068.4	3521.5 5542.7	2.00 3.15
Maryland	38 21 41.77	77 12 40.57	336 37 40 295 09 40	Grimes Wheat	156 38 07 115 11 29	2672.1 4692.8	2922.1 5131.9	1.66 2.92

GEOGRAPHICAL POSITIONS—Continued.

Section III.—Potomac River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Cleopatra	38 19 54.85	77 15 38.95	232 42 30	Maryland	52 44 21	5442.9	5952.2	3.38
			261 05 18	Grimes	81 07 36	5457.4	5968.1	3.39
Wagner	38 22 27.66	77 14 01.51	26 40 17	Cleopatra	206 39 16	5271.9	5765.2	3.28
			321 57 45	Grimes	141 59 02	4909.9	5369.3	3.05
Acquia Creek	38 22 09.65	77 17 36.08	325 36 22	Cleopatra	145 37 35	5035.8	5507.0	3.13
			276 48 23	Maryland	96 51 27	7224.6	7900.6	4.49
Dana	38 23 13.34	78 14 52.60	63 40 51	Acquia Creek	243 39 10	4427.2	4841.5	2.75
			10 25 22	Cleopatra	190 24 53	6222.3	6804.5	3.87
Brent	38 25 29.04	77 18 56.80	305 12 32	Dana	125 15 04	7252.7	7931.4	4.51
			342 19 28	Acquia Creek	162 20 18	6452.0	7055.7	4.01
Smith's Point	38 24 53.16	77 15 37.65	340 26 28	Dana	160 26 56	3265.7	3571.2	2.03
			102 55 03	Brent	282 52 59	4955.5	5419.2	3.08
Liverpool	38 27 46.41	77 15 56.78	355 02 01	Smith's Point	175 02 13	5361.3	5862.9	3.33
			45 52 55	Brent	225 51 03	6081.7	6650.8	3.78
Virginia	38 29 14.29	77 18 26.18	306 47 16	Liverpool	126 48 49	4522.4	4945.5	2.81
			6 06 12	Brent	186 05 53	6983.4	7636.8	4.34
Sandy	38 29 17.55	77 16 02.09	88 21 51	Virginia	268 20 21	3493.1	3820.0	2.17
			31 01 52	Brent	211 00 03	8219.5	8988.6	5.11
Chapowamsic	38 30 20.39	77 17 30.74	312 01 58	Sandy	132 02 53	2892.1	3162.7	1.80
			33 24 24	Virginia	213 23 49	2440.2	2668.5	1.52
Fairoak	38 30 34.42	77 15 31.98	81 27 20	Chapowamsic	261 26 06	2909.5	3181.7	1.81
			17 07 05	Sandy	197 06 46	2479.3	2711.3	1.54
Shipping Point	38 31 34.85	77 16 41.83	317 44 40	Fairoak	137 45 23	2516.5	2752.0	1.56
			27 18 16	Chapowamsic	207 17 46	2583.1	2824.8	1.61
Budd's Ferry	38 31 29.41	77 14 58.47	93 50 24	Shipping Point	273 49 20	2509.0	2743.7	1.56
			25 35 25	Fairoak	205 35 04	1879.4	2055.3	1.17
Cockpit Point	38 33 19.19	77 15 28.21	347 58 52	Budd's Ferry	167 59 11	3459.4	3783.1	2.15
			29 00 26	Shipping Point	208 59 40	3677.0	4021.1	2.28
Stump Neck	38 33 12.08	77 13 11.33	93 47 24	Cockpit Point	273 45 59	3321.0	3631.7	2.06
			39 21 10	Budd's Ferry	219 20 03	4092.2	4475.1	2.54
Freestone Point	38 35 30.48	77 14 31.61	335 30 14	Stump Neck	155 31 04	4687.5	5126.1	2.91
			18 42 19	Cockpit Point	198 41 44	4272.6	4672.3	2.66
Indian Head	38 35 53.84	77 10 43.91	82 34 13	Freestone Point	262 31 41	5556.4	6076.3	3.45
			35 35 58	Stump Neck	215 34 26	6131.3	6705.0	8.81
High Point	38 37 02.89	77 12 00.08	52 09 57	Freestone Point	232 08 22	4642.8	5077.3	2.88
			13 37 50	Stump Neck	193 37 06	7320.6	8005.6	4.55
Turtle	38 37 10.66	77 14 23.70	273 56 04	High Point	93 57 34	3482.4	3808.2	2.16
			3 32 44	Freestone Point	183 32 39	3094.3	3383.8	1.92
Occoquan	38 38 10.75	77 12 41.49	53 09 53	Turtle	233 08 49	3089.0	3378.0	1.92
			28 20 29	Freestone Point	208 19 20	5613.0	6138.2	3.49
Unpainted house, south chimney	38 23 45.78	77 14 58.94	118 54 26	Brent	298 51 58	6590.4	7207.0	4.09
			7 46 13	Cleopatra	187 45 48	7185.4	7857.7	4.46
Two-story house, chimney	38 22 06.11	77 10 34.78	31 54 34	Grimes	211 53 43	3773.3	4126.4	2.34
			336 31 10	Wheat	156 31 40	2994.6	3274.8	1.86
Black buoy off Maryland Point	38 21 07.25	77 11 59.76	67 15 59	Cleopatra	247 13 43	5771.5	6311.5	3.59
			357 09 19	Grimes	177 09 21	1390.2	1520.3	0.86
Unpainted house, south chimney	38 22 03.64	77 13 07.44	331 16 53	Grimes	151 17 37	3565.0	3898.6	2.21
			91 38 45	Acquia Creek	271 35 58	6523.7	7134.1	4.05
White house, white chimney	38 22 21.44	77 13 32.49	327 43 41	Grimes	147 44 40	4346.8	4753.5	2.70
			86 30 07	Acquia Creek	266 27 36	5923.7	6477.9	3.68
Fish-house, chimney	38 20 21.65	77 11 20.43	134 49 56	Wagner	314 48 16	5511.7	6027.5	3.42
			141 46 31	Maryland	321 45 41	3144.9	3439.2	1.95
Large fish-house, north gable end.	38 19 52.99	77 13 37.72	163 36 35	Dana	343 35 49	6439.1	7041.7	4.00
			202 28 24	Maryland	22 28 59	3629.7	3969.3	2.26
White fish-house, chimney	38 21 37.08	77 12 18.79	296 27 31	Wheat	116 29 06	4153.6	4542.2	2.58
			57 03 02	Cleopatra	237 00 58	5792.6	6334.6	3.60
White house near Acquia Creek, north chimney.	38 23 42.36	77 18 41.26	292 58 47	Maryland	113 02 31	9510.3	10400.1	5.91
			279 08 29	Dana	99 10 51	5620.3	6146.2	3.49
House at Marlborough Point, north chimney.	38 21 16.72	77 17 10.79	222 59 56	Dana	43 01 22	4917.0	5377.1	3.06
			318 31 48	Cleopatra	138 32 45	3368.2	3683.4	2.09

GEOGRAPHICAL POSITIONS—Continued.

Section III.—Potomac River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
House on Marlborough Hill, north chimney.	38 21 19.36	77 18 26.31	265 15 37	Maryland	85 19 12	8422.2	9210.3	5.23
			235 52 01	Dana	55 54 14	6264.8	6850.9	3.89
White house near Cleopatra, north chimney.	38 19 50.45	77 15 06.58	225 55 46	Maryland	45 57 17	4933.8	5395.5	3.07
			99 37 08	Cleopatra	279 36 48	798.0	872.7	0.50
Two-story brown house, south chimney, with white top.	38 24 18.35	77 15 15.46	112 06 48	Brent	292 04 31	5794.5	6336.7	3.60
			4 00 57	Cleopatra	184 00 42	8143.8	8905.9	5.06
House with portico over door, east chimney.	38 27 57.25	77 19 10.06	347 59 00	Aquia Creek	167 59 58	10956.9	11982.1	6.81
			355 58 30	Brent	175 58 38	4580.1	5008.6	2.85
Hoar's house, east chimney	38 29 27.87	77 18 21.81	275 21 27	Sandy	95 22 51	3399.8	3717.9	2.11
			14 13 11	Virginia	194 13 08	431.6	471.9	0.27
Posey's house, south chimney	38 31 29.80	77 14 03.76	92 20 32	Shipping Point	272 18 54	3831.5	4190.0	2.38
			89 28 37	Budd's Ferry	269 28 03	1325.0	1449.0	0.82
Chimney, with white top	38 31 18.56	77 17 00.52	222 01 48	Shipping Point	42 02 00	676.3	739.6	0.42
			263 31 57	Budd's Ferry	83 33 13	2975.1	3253.5	1.85
House at Shipping Point, north chimney.	38 31 13.62	77 17 01.84	216 31 03	Shipping Point	36 31 15	814.3	890.5	0.51
			299 01 28	Fair Oak	119 02 24	2489.7	2722.7	1.55
Ruins, tall red chimney	38 31 34.67	77 16 50.25	273 24 52	Budd's Ferry	93 26 02	2712.4	2966.2	1.69
			314 23 55	Fair Oak	134 24 44	2653.9	2902.3	1.65
Chicomoxen barn, south gable	38 31 38.28	77 13 35.49	169 15 22	Freestone Point	349 14 47	7285.0	7966.7	4.53
			191 25 47	Stump Neck	11 26 02	2950.1	3226.1	1.83
Cockpit Point, flag	38 33 33.78	77 15 05.61	283 34 43	Stump Neck	103 35 54	2846.2	3112.5	1.77
			50 34 13	Cockpit Point	230 33 59	708.5	774.8	0.44
Mast of old boat	38 32 13.35	77 14 20.64	70 52 24	Shipping Point	250 50 56	3619.3	3958.0	2.25
			34 05 18	Budd's Ferry	214 04 54	1635.6	1788.6	1.02
Freestone, flag	38 34 57.70	77 15 07.83	319 05 19	Stump Neck	139 06 32	4307.1	4710.1	2.68
			229 38 01	High Point	49 39 58	5959.9	6517.5	3.70
Fish-house, white chimney	38 35 21.54	77 14 33.20	229 50 55	High Point	49 52 31	4845.5	5298.9	3.01
			333 35 05	Stump Neck	153 35 56	4455.6	4872.5	2.77
Three small houses, northernmost chimney.	38 36 18.43	77 14 36.44	250 04 09	High Point	70 05 46	4023.1	4399.5	2.50
			340 15 59	Stump Neck	160 16 52	6102.1	6673.1	3.79
House with six chimneys, center chimney on south end.	38 34 19.49	77 12 04.96	147 32 45	Turtle	327 31 19	6253.8	6839.0	3.89
			121 40 00	Freestone Point	301 38 29	4169.3	4559.4	2.59
Sycamore	38 37 28.80	77 09 56.56	75 02 17	High Point	255 01 00	3092.5	3381.8	1.92
			21 22 31	Indian Head	201 22 01	3143.4	3437.5	1.95
North Indian Head	38 36 20.45	77 09 54.39	113 17 31	High Point	293 16 13	3309.9	3619.6	2.06
			178 34 21	Sycamore	358 34 20	2107.9	2305.1	1.31
Pye's Wharf	38 36 38.30	77 07 57.02	79 02 35	North Indian Head	259 01 22	2892.3	3162.9	1.80
			118 18 37	Sycamore	298 17 22	3284.1	3591.4	2.04
Hallowing Point	38 38 02.00	77 07 33.41	12 28 49	Pye's Wharf	192 28 34	2642.6	2889.8	1.64
			73 32 50	Sycamore	253 31 21	3610.1	3947.9	2.24
Pamunkey Creek	38 38 00.56	77 06 21.41	91 28 02	Hallowing Point	271 27 17	1741.9	1904.9	1.08
			42 22 23	Pye's Wharf	222 21 23	3431.9	3753.0	2.13
Gut Landing	38 39 47.19	77 06 39.27	21 59 15	Hallowing Point	201 58 41	3497.0	3824.3	2.17
			352 30 42	Pamunkey Creek	172 30 53	3315.4	3625.6	2.06
Gunsen Cove	38 39 16.52	77 08 20.77	248 54 54	Gut Landing	68 55 57	2629.5	2875.6	1.63
			309 02 28	Pamunkey Creek	129 03 43	3716.6	4064.3	2.31
White Stone Point	38 40 30.82	77 07 30.53	27 56 25	Gunsen Cove	207 55 54	2592.4	2834.9	1.61
			340 09 19	Pamunkey Creek	160 10 02	4924.0	5384.8	3.06
Stevenson	38 40 12.48	77 06 35.72	55 49 20	Gunsen Cove	235 48 14	3069.9	3357.1	1.91
			113 06 53	White Stone Point	293 06 19	1440.3	1575.0	0.90
Terry Point	38 41 46.31	77 06 00.00	43 14 29	White Stone Point	223 13 32	3193.7	3492.5	1.98
			16 37 18	Stevenson	196 36 56	3018.4	3300.8	1.88
Marshal Point	38 41 05.95	77 05 42.95	67 23 51	White Stone Point	247 22 44	2816.3	3079.8	1.75
			161 40 39	Stevenson	341 40 28	1310.4	1433.0	0.81
Bryant's Point	38 41 40.52	77 03 48.58	68 55 21	Marshal Point	248 54 10	2962.0	3239.2	1.84
			93 13 31	Ferry Point	273 12 09	3180.4	3478.0	1.98
Hunting Creek	38 42 27.88	77 04 32.14	34 07 27	Marshal Point	214 06 43	3050.6	3336.1	1.90
			324 12 48	Bryant's Point	144 13 15	1799.5	1967.9	1.12
Fish-house near Sycamore, white chimney.	38 37 30.38	77 09 49.35	300 34 09	Pye's Wharf	120 35 19	3155.9	3451.2	1.96
			3 14 23	North Indian Head	183 14 20	2159.2	2361.3	1.34

GEOGRAPHICAL POSITIONS—Continued.

Section III.—Potomac River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Fish-house, west gable	38 36 17.46	77 09 02.34	247 52 11 149 11 39	Pye's wharf Sycamore	67 52 52 329 11 05	1705.8 2560.8	1865.4 2800.4	1.06 1.59
Fish-house, near Indian Head	38 36 19.86	77 09 46.49	257 52 41 173 27 50	Pye's wharf Sycamore	77 53 49 353 27 44	2708.8 2139.2	2962.2 2339.4	1.68 1.33
Glymont Pavilion	38 36 33.02	77 08 05.44	195 46 15 222 59 33	Hallowing Point Pamunkey Creek	15 46 35 43 00 38	2850.1 3689.6	3116.8 4034.8	1.77 2.29
Fish-house, chimney	38 37 09.49	77 07 06.49	158 05 23 214 42 16	Hallowing Point Pamunkey Creek	338 05 06 34 42 44	1744.7 1915.0	1907.9 2094.2	1.08 1.19
House on Craney Island, east chimney.	38 37 29.07	77 08 00.30	247 54 25 354 05 53	Pamunkey Creek Pye's wharf	67 55 27 177 05 55	2581.1 1567.3	2822.6 1714.0	1.60 0.97
Chapman's house, cupola	38 37 01.03	77 06 39.96	145 28 55 193 44 15	Hallowing Point Pamunkey Creek	325 28 22 13 44 27	2281.2 1889.2	2494.6 2066.0	1.42 1.17
Old house, chimney	38 39 14.37	77 08 19.14	247 14 58 308 37 15	Gut Landing Pamunkey Creek	67 16 00 128 38 28	2617.8 3644.2	2862.7 3985.2	1.63 2.26
High tree	38 39 01.57	77 08 23.18	204 49 32 240 45 03	Whitestone Point Gut Landing	24 50 05 60 46 08	3031.2 2879.0	3314.8 3148.3	1.88 1.79
Long House, chimney in center	38 39 01.32	77 06 28.41	99 47 40 151 26 48	Gunsen Cove White Stone Point	279 46 30 331 26 09	2756.6 3140.9	3014.5 3434.8	1.71 1.95
Briscoe	38 40 51.02	77 06 03.22	33 28 22 73 34 00	Stevenson White Stone Point	213 28 02 253 33 05	1424.1 2200.3	1557.4 2406.2	0.89 1.37
White House Pavilion	38 40 45.36	77 07 17.56	315 03 19 224 55 19	Stevenson Ferry Point	135 03 45 44 56 08	1431.6 2653.9	1565.5 2902.3	0.89 1.65
White chimney on Ferry Point	38 41 47.41	77 05 58.78	343 20 07 373 51 07	Marshal Point Bryant's Point	163 20 17 93 52 28	1334.2 3153.1	1459.0 3448.1	0.83 1.96
Mount Vernon wharf, sign-board	38 42 15.94	77 05 01.55	24 52 49 301 45 35	Marshal Point Bryant's Point	204 52 23 121 46 21	2378.0 2073.6	2600.5 2267.6	1.48 1.29
Target	38 42 27.29	77 02 53.00	90 26 37 42 58 36	Hunting Creek Bryant's Point	270 25 35 222 58 01	2395.1 1970.3	2619.2 2154.6	1.49 1.22
Fort Washington, flag-staff	38 42 36.81	77 01 47.85	86 02 45 59 15 50	Hunting Creek Bryant's Point	266 01 02 239 14 34	3978.3 3394.1	4350.6 3711.7	2.47 2.11
Mockley Point	38 42 03.99	77 02 27.05	103 42 22 49 50 37	Hunting Creek Bryant's Point	283 41 04 249 49 46	3110.5 2098.7	3401.5 2295.1	1.93 1.30
Fort Washington	38 42 41.90	77 01 52.77	55 56 30 35 19 32	Bryant's Point Mockley Point	235 55 18 215 19 11	3377.8 1432.5	3693.8 1566.5	2.10 0.89
Sheridan Point	38 43 16.96	77 02 14.93	333 38 36 7 25 07	Fort Washington Mockley Point	153 38 50 187 24 59	1205.9 2268.3	1318.8 2480.6	0.75 1.41
Broad Creek	33 44 11.43	77 01 27.91	12 16 44 34 04 37	Fort Washington Sheridan Point	192 16 28 214 04 08	2824.2 2027.1	3088.5 2216.8	1.75 1.26
Red House Point	38 44 24.59	77 02 14.87	289 40 40 350 25 30	Broad Creek Fort Washington	109 41 09 170 25 11	1204.5 3210.0	1317.2 3510.4	0.75 1.99
Rosier's Bluff	38 46 16.81	77 01 32.78	358 15 25 16 22 36	Broad Creek Red House Point	178 15 28 196 22 10	3866.7 3605.4	4228.5 3942.7	2.40 2.24
Hell Hole Point	38 45 57.19	77 02 10.65	236 30 27 342 25 46	Rosier's Bluff Broad Creek	56 30 51 162 26 13	1096.2 3419.3	1198.8 3739.3	0.68 2.12
Fox Ferry	38 48 03.41	77.01 18.09	18 03 43 6 09 31	Hell Hole Point Rosier's Bluff	198 03 10 186 09 22	4092.6 3305.2	4475.5 3614.5	2.54 2.05
Fish-house, west chimney	38 43 09.31	77 01 33.38	29 00 21 103 13 57	Fort Washington Sheridan Point	209 00 09 283 13 31	965.7 1030 9	1056.0 1127.4	0.60 0.64
White-House, west chimney	38 45 27.93	77 01 13.50	123 10 20 37 12 10	Hell Hole Point Red House Point	303 09 44 217 11 32	1648.2 2451.2	1802.5 2680.5	1.02 1.52
Pioneer Mills, chimney	38 48 02.46	77 02 06.39	268 32 42 346 00 39	Fox Ferry Rosier's Bluff	88 33 12 166 01 00	1165.8 3356.1	1274.8 3670.2	0.72 2.09
Unpainted house, chimney	38 44 31.88	77 00 59.48	146 50 34 82 58 38	Hell Hole Point Red House Point	326 49 50 262 57 51	3141.4 1834.5	3435.3 2006.1	1.95 1.14
Vicinity of Washington City, D. C.								
CAUSTEN	38 55 31 96	77 04 05.29						
SEMINARY, OLD	38 49 10.24	77 05 13.72	187 58 16	Causten	7 58 59	11884.7	12996.7	7.38
Naval Observatory signal, (east station.)	38 53 38.96	77 02 47.29	151 40 03 23 05 25	Causten Seminary, old	331 39 14 203 03 53	3958.6 9006.2	4329.0 9848.9	2.46 5.60

GEOGRAPHICAL POSITIONS—Continued.

Section III.—Vicinity of Washington City, D. C.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Miles.*	*Yards.*	*Miles.*
Coast Survey Office	38 53 07.06	77 00 11.46	44 58 13	Seminary, old	224 55 04	10316.2	11281.5	6.41
			104 41 37	Naval Observat'y, signal	284 39 59	3881.8	4245.1	2.41
Seminary, new steeple	38 49 10.16	77 05 12.86	202 56 15	Naval Observat'y, signal	22 57 46	9090.1	9842.2	5.59
			224 49 38	Coast Survey Office	44 52 47	10303.0	11267.1	6.40
Lunatic Asylum	38 51 13.81	76 59 42.37	135 08 02	Naval Observat'y, signal	315 06 06	6315.9	6906.9	3.92
			64 27 47	Seminary, new steeple	244 24 20	8834.5	9661.1	5.49
Military Asylum	38 56 26.49	77 00 21.88	34 09 13	Naval Observat'y, signal	214 07 42	6241.1	6825.1	3.88
			292 48 27	Hill	112 53 23	12304.0	13455.3	7.65
Oxon Hill	38 47 55.14	77 00 05.17	107 20 18	Seminary, new steeple	287 17 05	7774.9	8502.4	4.83
			159 46 26	Naval Observat'y, signal	339 44 44	11298.9	12356.1	7.02
Kengley's house, southeast chimney.	38 55 31.23	77 04 07.59	7 37 50	Seminary, new steeple	187 37 09	11854.4	12963.6	7.37
			307 58 59	Coast Survey Office	128 01 27	7219.9	7895.4	4.49
Miner's Hill	38 54 20.54	77 09 15.14	253 34 45	Kengley's house, south-east chimney.	73 37 58	7722.3	8444.9	4.80
			328 34 58	Seminary, new steeple	148 37 30	11211.6	12260.6	6.97
Blunt's house, center of cupola	38 56 39.40	77 04 37.86	57 21 36	Miner's Hill	237 18 42	7933.1	8675.4	4.93
			340 52 32	Kengley's house, south-east chimney.	160 52 51	2224.8	2432.9	1.38
Upton's Hill	38 52 16.15	77 08 31.51	226 34 09	Kengley's house, south-east chimney.	46 36 55	8753.0	9572.0	5.44
			164 40 26	Miner's Hill	344 39 59	3976.9	4349.0	2.47
Falls Church	38 52 49.05	77 09 54.68	296 50 02	Upton's Hill	116 50 54	2246.6	2456.8	1.40
			198 39 32	Miner's Hill	18 39 57	2977.5	3256.1	1.85
Lewinsville Church, south gable	38 55 43.40	77 11 32.19	307 43 28	Miner's Hill	127 44 54	4174.5	4565.1	2.59
			260 08 46	Blunt's house	80 13 06	10126.1	11073.6	6.29
Langley Church, south gable	38 56 47.73	77 09 19.36	358 42 59	Miner's Hill	178 43 02	4539.6	4964.4	2.82
			272 08 43	Blunt's house	92 11 40	6782.9	7417.6	4.21
Offut's house	39 00 22.68	77 10 56.34	347 40 57	Miner's Hill	167 42 01	11429.1	12498.6	7.10
			307 02 53	Blunt's house	127 06 51	11418.5	12486.9	7.09
Hall's house, center of cupola	38 54 16.54	77 07 26.40	244 17 28	Kengley's house, south-east chimney.	64 19 33	5312.4	5809.5	3.30
			222 38 04	Blunt's house	42 39 50	5989.1	6549.5	3.72
Naval Observatory, dome	38 53 38.90	77 02 47.58	315 02 44	Lunatic Asylum	135 04 40	6319.5	6910.8	3.93
			284 36 50	Coast Survey Office	104 38 28	3888.0	4251.8	2.42
Fort Lincoln, signal	38 55 30.53	76 57 12.99	44 38 40	Seminary, new steeple	224 33 39	16471.9	18013.2	10.23
			110 47 14	Military Asylum	290 45 15	4865.1	5320.3	3.02
Agricultural College	38 58 57.57	76 56 19.29	51 26 30	Military Asylum	231 23 57	7469.7	8168.6	4.64
			11 27 18	Fort Lincoln, signal	191 26 44	6513.7	7123.1	4.05
Brick house, cupola	38 58 39.36	76 57 15.26	47 39 11	Military Asylum	227 37 14	6080.1	6649.0	3.78
			359 27 43	Fort Lincoln, signal	179 27 44	5822.5	6367.3	3.62
Yellow Roof, white cupola	38 56 43.42	76 56 14.76	85 00 29	Military Asylum	264 57 54	5973.2	6532.1	3.71
			31 58 06	Fort Lincoln, signal	211 57 29	2649.0	2866.8	1.65
Fort Manning, red chimney	38 53 40.09	76 56 22.45	131 40 43	Military Asylum	311 38 13	7718.3	8440.5	4.80
			266 20 58	Hill	86 23 23	5584.0	6106.5	3.47
Yellow Mill, south apex	38 56 27.94	76 55 47.53	89 38 06	Military Asylum	269 35 14	6606.4	7224.6	4.10
			49 18 33	Fort Lincoln, signal	229 17 39	2714.6	2968.6	1.69
Bladensburg Church, east apex	38 56 22.76	76 56 08.71	91 06 08	Military Asylum	271 03 29	6097.2	6667.7	3.79
			43 52 19	Fort Lincoln, signal	223 51 39	2233.6	2442.6	1.39
Painted house, south apex	36 56 12.37	76 55 46.81	93 47 02	Military Asylum	273 44 09	6638.0	7259.1	4.12
			58 08 38	Fort Lincoln, signal	238 07 44	2443.7	2672.3	1.52
Fort Lincoln, flag-staff	38 55 31.61	76 57 12.68	12 38 34	Fort Lincoln, signal	192 38 34	34.1	37.3	0.02
			110 23 23	Military Asylum	290 21 24	4860.4	5315.1	3.02
Old house, pipe chimney	38 57 48.13	77 01 20.60	299 43 40	Hill	119 49 13	14690.2	16064.7	9.13
			330 40 30	Military Asylum	150 41 07	2887.1	3157.3	1.79
Gray house, white cupola	38 57 32.00	77 01 20.20	325 11 25	Military Asylum	145 12 02	2460.1	2690.3	1.53
			298 02 01	Hill	118 07 33	14441.6	15792.8	8.97
Brick church, south apex	38 57 47.06	77 01 23.72	299 28 18	Hill	119 33 53	14739.4	16118.6	9.16
			329 03 33	Military Asylum	149 01 12	2896.6	3167.6	1.80
Keyser's house, west chimney	38 51 00.02	76 58 15.85	101 32 02	Lunatic Asylum	281 31 08	2128.9	2328.1	1.32
			163 13 32	Military Asylum	343 12 13	10514.1	11497.9	6.53
Gray house, southwest vane flag	38 51 30.82	76 58 26.28	74 03 36	Lunatic Asylum	254 02 48	1907.8	2086.3	1.19
			163 01 26	Military Asylum	343 00 13	9532.4	10424.3	5.92

GEOGRAPHICAL POSITIONS.—Continued.

Section III.—Vicinity of Washington City, D. C.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Almshouse, southeast chimney	38 53 03.32	76 58 17.90	31 06 01	Lunatic Asylum	211 05 08	3942.8	4311.8	2.45
			154 31 21	Military Asylum........	334 30 03	6939.8	7589.1	4.31
U. S. Arsenal, flag-staff	38 51 48.47	77 00 45.58	183 48 38	Military Asylum........	3 48 53	8591.2	9395.1	5.35
			305 02 08	Lunatic Asylum	125 02 48	1861.1	2035.2	1.16
Fort Carroll, flag-staff..........	38 50 15.25	77 00 04.72	148 03 19	Naval Observat'y, signal	328 01 37	7403.1	8095.8	4.60
			196 36 49	Lunatic Asylum	16 37 03	1884.5	2060.8	1.17
Jones Point light-house.........	38 47 21.97	77 02 08.58	206 14 36	Lunatic Asylum	26 16 08	7970.8	8716.6	4.95
			251 02 28	Oxon Hill..............	71 03 45	3148.6	3443.2	1.96
Young's house, Geesborough Point.	38 50 53.80	77 00 48.93	192 23 53	Coast Survey Office	12 24 17	4206.8	4600.4	2.61
			246 57 25	Lunatic Asylum	68 58 07	1719.3	1880.2	1.07
Arlington House, east apex	38 52 48.81	77 04 03.36	218 27 54	Military Asylum........	38 30 13	8574.2	9376.5	5.33
			294 56 36	Lunatic Asylum	114 59 20	6939.5	7588.8	4.31
Hospital house, cupola	38 52 00.45	77 03 49.00	206 04 08	Naval Observat'y, signal	26 04 47	3381.4	3697.8	2.10
			211 18 08	Military Asylum	31 20 18	9601.6	10500.0	5.97
White House, cupola	38 51 28.96	77 03 42.21	207 44 17	Military Asylum	27 46 23	10366.5	11336.5	6.44
			274 35 50	Lunatic Asylum	94 38 20	5801.7	6344.6	3.60
Georgetown College, east tower	38 54 23.90	77 04 05.13	306 27 17	Naval Observat'y, signal	126 28 06	2331.7	2549.9	1.45
			312 45 48	Lunatic Asylum	132 48 33	8628.3	9435.7	5.36
Foundry No. 1, black pipe	38 52 23.75	76 59 22.83	115 13 16	Naval Observat'y, signal	295 11 07	5445.4	5954.9	3.38
			12 19 21	Lunatic Asylum	192 19 09	2207.2	2413.8	1.37
Foundry No. 2, red pipe	38 52 23.98	76 59 28.43	115 46 22	Naval Observat'y, signal	295 44 17	5320.6	5818.5	3.31
			8 49 48	Lunatic Asylum	188 49 39	2189.1	2394.0	1.36
Smithsonian Institution, rod on highest tower.	38 53 16.64	77 01 16.18	280 44 27	Coast Survey Office	100 45 08	1587.5	1736.0	0.99
			192 35 44	Military Asylum........	12 36 18	5998.4	6559.7	3.73
Washington Defenses.								
Fort Ethan Allen, flag-staff....	38 55 23.41	77 07 11.15	296 52 55	Naval Observatory, dome	116 55 41	7121.2	7787.5	4.43
			346 04 46	Seminary, new steeple ..	166 06 00	11856.2	12965.6	7.37
Battery Cameron, flag-staff....	38 54 50.00	77 04 59.19	73 47 17	Hall's house	253 45 45	3693.9	4039.6	2.29
			107 58 49	Ft. Ethan Allen, flag-staff	287 57 26	3341.4	3654.0	2.08
Fort Marcy, flag-staff...........	38 56 03.17	77 07 16.93	304 12 30	Batt'y Cameron, flag-staff	124 13 56	4012.9	4388.4	2.49
			253 43 12	Blunt's house	73 44 52	3989.6	4362.9	2.48
Battery Kemble, station........	38 55 46.32	77 05 28.08	338 09 58	Batt'y Cameron, flag-staff	158 10 16	1869.9	3044.8	1.16
			45 49 53	Hall's house	225 48 39	3973.5	4345.3	2.47
Battery Parrott, station	38 55 11.47	77 05 08.29	341 37 48	Batt'y Cameron, flag-staff	161 37 54	697.7	763.0	0.43
			247 21 42	Kengley's house	67 22 20	1583.4	1731.5	0.98
Battery Vermont, flag-staff....	38 56 09.86	77 06 15.64	302 22 03	Battery Kemble.........	122 22 33	1356.5	1483.4	0.84
			82 04 14	Fort Marcy, flag-staff ...	262 03 36	1490.6	1630.1	0.93
Fort DeKalb, flag-staff..........	38 53 44.68	77 05 00.71	273 09 51	Naval Observatory, dome	93 11 15	3213.5	3514.2	2.00
			201 17 06	Kengley's house	21 17 39	3526.1	3856.1	2.19
Fort Woodbury, flag staff.......	38 53 20.11	77 04 41.02	147 58 05	Fort DeKalb, flag-staff ..	327 57 53	893.9	977.6	0.56
			258 01 33	Naval Observatory, dome	78 02 44	2793.7	3055.1	1.74
Arlington, flag-staff in front of house.	38 52 48.80	77 04 02.60	264 12 27	Coast Survey Office	84 14 52	5599.0	6122.8	3.48
			295 00 29	Lunatic Asylum	115 03 12	6922.4	7570.1	4.30
Fort Corcoran, flag-staff	38 53 39.80	77 04 15.92	270 45 09	Naval Observatory, dome	90 46 04	2128.4	2327.6	1.32
			348 26 43	Arlington, flag-staff.....	168 26 51	1604.8	1754.9	1.00
Fort Cass, flag-staff.............	38 53 02.05	77 04 43.03	209 17 35	Fort Corcoran, flag-staff .	29 17 52	1334.4	1459.2	0.83
			268 37 37	Coast Survey Office	88 40 28	6546.4	7158.9	4.07
Fort Tillinghast, flag-staff......	38 52 41.87	77 04 44.35	237 59 15	Naval Observatory, dome	58 00 28	3318.9	3629.4	2.06
			168 28 45	Fort DeKalb, flag-staff ..	348 28 35	1976.0	2160.9	1.23
Fort Bennett, flag-staff	38 53 54.18	77 04 23.20	281 32 57	Naval Observatory, dome	101 33 57	2351.8	2571.9	1.46
			187 10 13	Kengley's house	7 10 23	3015.3	3297.4	1.87
Fort Sumner, Redoubt Kirby, flag-staff, (Fort Franklin.)	38 57 19.02	77 07 08.00	1 13 00	Ft. Ethan Allen, flag-st'ff	181 12 58	3565.9	3899.6	2.22
			5 15 02	Fort Marcy, flag-staff ...	185 14 56	2348.3	2568.0	1.46
Fort Sumner, Redoubt Cross, flag-staff, (Fort Ripley.)	38 57 13.73	77 07 03.86	2 56 43	Ft. Ethan Allen, flag-st'ff	182 56 38	3405.8	3724.4	2.12
			8 14 12	Fort Marcy, flag-staff ...	188 14 04	2198.2	2403.9	1.37
Fort Sumner, Redoubt Davis, flag-staff, (Fort Alexander.)	38 57 15.13	77 07 11.50	3 42 46	Hall's house	183 42 37	5515.3	6031.4	3.43
			317 39 20	Battery Kemble	137 40 25	3699.5	4045.7	2.30
Fort Sumner, camp, flag-staff ...	38 57 11.98	77 07 10.33	194 31 10	Redoubt Kirby, flag-staff.	14 31 11	224.4	245.4	0.14
			163 45 59	Redoubt Davis, flag-staff.	343 45 58	101.2	110.7	0.06

GEOGRAPHICAL POSITIONS—Continued.

Section III.—Washington Defenses.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Fort Gaines, flag-staff	38 56 18.23	77 04 56.22	118 18 48	Redoubt Davis, flag-staff.	298 17 23	3699.7	4045.9	2.30
			119 07 23	Redoubt Cross, flag-staff.	299 06 03	3517.5	3846.6	2.19
Battery Scott, station	38 55 46.35	77 06 22.90	193 35 18	Batt'y Vermont, flag-staff	13 35 23	745.7	815.4	0.46
			159 11 10	Redoubt Kirby, flag-staff	339 10 42	3057.1	3343.2	1.90
Fort Mansfield, flag-staff	38 57 06.08	77 05 48.55	319 30 05	Fort Gaines, flag-staff	139 30 38	1940.6	2122.2	1.21
			101 47 43	Redoubt Kirby, flag-staff	281 46 53	1954.3	2137.2	1.21
Fort C. F. Smith, station, (Fort McDowell.)	38 54 01.16	77 05 11.17	281 12 45	Naval Observatory, dome	101 14 15	3527.6	3857.7	2.19
			296 18 29	Fort Corcoran, flag-staff.	116 19 04	1484.8	1623.7	0.92
Fort Reno, old flag-staff	38 57 07.22	77 04 23.22	39 59 40	Hall's house	219 57 45	6869.4	7512.2	4.27
			282 09 56	Military Asylum	102 12 28	5945.6	6501.9	3.69
Fort Reno, new flag-staff, (after April 27, 1863.)	38 57 07.21	77 04 23.13	40 00 19	Hall's house	219 58 24	6868.6	7511.3	4.27
			85 12 42	Langley church	265 09 36	7157.5	7827.2	4.45
Fort Kearney, flag-staff	38 57 12.46	77 03 25.42	59 43 24	Blunt's house	239 42 39	2020.6	2209.7	1.26
			83 21 36	Fort Reno, old flag-staff	263 21 00	1400.3	1531.3	0.87
Fort Lincoln, new flag-staff	38 55 27.51	76 57 14.95	191 40 33	Agricultural College	11 41 08	6614.3	7233.2	4.11
			112 00 52	Military Asylum	291 58 55	4855.0	5309.3	3.02
Fort Saratoga, flag-staff	38 55 43.18	76 58 25.50	115 29 13	Military Asylum	295 28 00	3105.2	3395.8	1.93
			285 52 42	Ft. Lincoln, new flag staff	105 53 26	1767.4	1932.8	1.10
Fort Totten, flag-staff	38 56 48.81	76 59 59.72	311 43 25	Fort Saratoga, flag-staff	131 44 24	3040.5	3324.9	1.89
			37 48 11	Military Asylum	217 48 27	871.0	952.5	0.54
Fort Bunker Hill, flag-staff	38 56 03.66	76 59 00.41	109 44 10	Military Asylum	289 43 19	2084.5	2279.5	1.30
			306 53 52	Fort Saratoga, flag-staff	126 54 14	1051.8	1150.2	0.65
Battery Slemmer, flag-staff	38 56 18.77	76 59 42.91	294 27 44	Ft. Bunker Hill, flag-staff	114 28 11	1124.0	1229.2	0.70
			300 28 56	Fort Saratoga, flag-staff	120 29 45	2163.7	2366.1	1.34
Fort Slocum, flag-staff	38 57 33.71	77 00 20.12	320 59 27	Fort Saratoga, flag-staff	141 00 39	4385.9	4796.3	2.73
			1 10 45	Military Asylum	181 10 44	2073.0	2267.0	1.29
Fort Thayer, flag-staff	38 55 38.62	76 57 59.98	117 57 34	Ft. Bunker Hill, flag-staff	297 56 56	1648.7	1803.0	1.02
			113 22 10	Military Asylum	293 20 41	3722.5	4070.8	2.31
Fort Stevens, flag-staff	38 57 47.16	77 01 23.57	311 42 14	Fort Totten, flag-staff	131 43 07	2704 3	2957.3	1.68
			285 10 22	Fort Slocum, flag-staff	105 11 02	1582.7	1730.8	0.98
Fort DeRussy, station on parapet.	38 57 45.63	77 02 45.36	52 59 50	Blunt's House	232 58 39	3392.4	3709.8	2.11
			268 36 56	Fort Stevens, flag-staff	88 37 47	1969.8	2154.1	1.22
Fort Mahan, flag-staff	38 53 39.52	76 56 22.78	79 43 49	Coast Survey Office	259 41 25	5600.6	6124.7	3.48
			159 19 03	Ft. Lincoln, new flag-st'ff	339 18 30	3558.5	3891.5	2.21
Fort Bayard, small flag-staff	38 57 15.64	77 05 10.68	348 51 25	Fort Gaines, flag-staff	168 51 34	1803.3	1972.0	1.12
			324 44 02	Blunt's House	144 44 23	1368.7	1496.7	0.85
Fort Simmons, flag-staff	38 57 03.27	77 05 33.57	298 44 59	Blunt's House	118 45 34	1529.1	1672.2	0.95
			235 14 17	Fort Bayard, flag-staff	55 14 31	669.9	732.6	0.42
Fort Richardson, flag-staff	38 51 25.69	77 04 24.75	15 31 04	Seminary, new steeple	195 30 34	4335.9	4741.7	2.69
			209 40 53	Naval Observatory, dome	29 41 54	4727.4	5169.7	2.94
Fort Albany, flag-staff	38 51 51.82	77 03 40.72	24 02 07	Seminary, new steeple	204 01 09	5456.8	5967.4	3.39
			201 12 02	Naval Observatory, dome	21 12 35	3541.4	3872.7	2.20
Fort Greble, flag-staff	38 49 29.78	77 00 37.04	157 43 51	Naval Observatory, dome	337 42 29	8300.7	9077.4	5.16
			202 19 51	Lunatic Asylum	22 20 25	3468.4	3792.9	2.15
Fort Meigs, flag-staff	38 52 23.10	76 55 32.16	156 27 54	Ft. Lincoln, new flag-staff	336 26 49	6201.3	6781.5	3.85
			101 24 49	Coast Survey Office	281 21 54	6865.5	7507.9	4.27
Fort Scott, flag-staff	38 50 48.24	77 03 17.00	163 43 28	Fort Albany, flag-staff	343 43 13	2041.7	2232.8	1.27
			261 18 48	Lunatic Asylum	81 21 03	5234.5	5724.3	3.25
Fort Carroll, new flag-staff	38 50 13.35	77 00 05.94	29 10 42	Fort Greble, flag-staff	209 10 22	1538.0	1681.9	0.96
			196 57 19	Lunatic Asylum	16 57 34	1949.3	2131.7	1.21
Fort Craig, flag-staff	38 52 10.22	77 04 34.90	254 32 55	Coast Survey Office	74 35 41	6586.5	7202.8	4.09
			349 53 06	Ft. Richardson, flag-staff.	169 53 12	1394.6	1525.1	0.87
Fort Barnard, flag-staff	38 50 54.20	77 05 14.55	231 02 41	Ft. Richardson, flag-staff.	51 03 12	1544.0	1688.5	0.96
			265 39 08	Lunatic Asylum	85 42 36	8031.3	8782.8	4.99
Fort Blenker, flag-staff	38 50 14.42	77 05 16.80	257 10 32	Lunatic Asylum	77 14 02	8268.8	9042.5	5.14
			209 43 51	Ft. Richardson, flag-staff.	29 44 24	2530.5	2767.2	1.57
Fort Ward, flag-staff	38 49 45.83	77 05 50.09	211 27 25	Naval Observatory, dome	31 29 20	8425.1	9213.5	5.24
			320 41 10	Seminary, new steeple	140 41 33	1419.6	1552.4	0.88
Fort Ramsay, flag-staff	38 52 18.87	77 08 32.29	227 03 32	Kengley's house	47 06 16	8709.4	9524.4	5.41
			251 15 16	Ft. Woodbury, flag-staff	71 17 41	5884.0	6434.6	3.66

GEOGRAPHICAL POSITIONS—Continued.

Section III.—Washington Defenses.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Fort Ellsworth, flag-staff	38 48 27.07	77 03 55.66	125 31 10	Seminary, new steeple	305 30 22	2287.8	2501.8	1.42
			212 02 07	Coast Survey Office	32 04 28	10186.1	11139.2	6.33
Fort Lyon, flag-staff	38 47 31.77	77 04 20.56	224 22 57	Lunatic Asylum	44 25 51	9586.3	10483.3	5.96
			157 24 36	Seminary, new steeple	337 24 03	3288.2	3595.9	2.04
Fort Worth, flag-staff	38 48 52.32	77 05 37.52	282 22 37	Oxon Hill	102 26 05	8208.7	8976.8	5.10
			242 58 35	Lunatic Asylum	63 02 17	9610.8	10510.1	5.97
Fort Buffalo, station	38 52 15.06	77 09 07.24	315 13 34	Seminary, new steeple	135 16 01	8027.0	8778.1	4.99
			262 03 22	Fort Ramsay, flag-staff	82 03 44	851.1	930.7	0.53
Munson's Hill, flag	38 51 32.97	77 08 25.59	313 25 53	Seminary, new steeple	133 27 54	6401.4	7000.3	3.98
			173 29 37	Fort Ramsay, flag-staff.	353 29 33	1424.8	1558.1	0.89
Fort Dupont, flag-staff	38 52 19.00	76 56 07.48	171 33 33	Fort Mahan, flag-staff	351 33 23	2510.2	2745.1	1.56
			261 31 38	Fort Meigs, flag-staff	81 32 00	860.4	940.9	0.53
Fort Ricketts, flag-staff	38 51 21.40	76 58 14.01	139 01 31	Coast Survey Office	319 00 17	4315.8	4719.6	2.68
			83 44 56	Lunatic Asylum	263 44 01	2143.2	2343.7	1.33
Fort Stanton, flag-staff	38 51 26.44	76 58 36.12	76 18 51	Lunatic Asylum	256 18 09	1644.4	1798.3	1.02
			143 29 11	Coast Survey Office	323 28 11	3860.4	4221.6	2.40
Fort Snyder, flag-staff	38 50 39.05	76 59 02.61	203 39 32	Fort Stanton, flag-staff	23 39 49	1595.6	1744.9	0.99
			138 13 31	Lunatic Asylum	318 13 06	1437.6	1572.1	0.89
Fort Wagner, flag-staff	38 51 31.45	76 57 52.15	131 17 39	Coast Survey Office	311 16 11	4469.1	4887.3	2.78
			59 27 17	Fort Ricketts, flag-staff.	239 27 03	611.5	668.7	0.38
Fort Baker, flag-staff	38 51 37.76	76 57 33.96	155 34 28	Military Asylum	335 32 43	9778.9	10693.9	6.08
			125 57 48	Coast Survey Office	305 56 09	4689.4	5128.2	2.91
Fort Davis, flag-staff	38 51 56.54	76 56 47.91	63 27 57	Fort Wagner, flag-staff	243 27 17	1731.1	1893.1	1.08
			62 27 03	Fort Baker, flag-staff	242 26 34	1251.9	1369.1	0.78
Montgomery Blair's house	38 59 25.92	77 01 38.41	42 51 45	Fort Reno, old flag-staff	222 50 01	5833.9	6379.8	3.62
			341 34 32	Military Asylum	161 35 20	5830.9	6376.5	3.62
Headquarters flag-staff near Fort Corcoran.	38 53 46.68	77 04 11.35	276 46 17	Naval Observatory, dome	96 47 10	2033.2	2223.4	1.26
			27 25 26	Fort Corcoran, flag-staff	207 25 23	238.4	260.7	0.15
Alexandria and vicinity.								
Lyon	38 47 23.06	77 04 19.30	260 48 53	Oxon Hill	80 51 32	6211.4	6792.6	3.86
			223 09 59	Lunatic Asylum	43 12 53	9759.0	10672.1	6.06
Erin	38 46 45.23	77 05 36.02	254 51 46	Oxon Hill	74 55 13	8269.8	9043.6	5.14
			237 46 41	Lyon	57 47 29	2188.3	2393.1	1.36
Worth	38 48 49.55	77 05 37.06	324 52 03	Lyon	144 52 52	3260.5	3565.5	2.03
			281 48 16	Oxon Hill	101 51 44	8180.9	8946.4	5.08
Ellsworth	38 48 26.65	77 03 51.45	280 04 25	Oxon Hill	100 06 47	5545.1	6064.0	3.45
			18 55 19	Lyon	198 55 02	2072.8	2266.8	1.29
Gravelly	38 51 57.57	77 01 53.94	229 03 24	Coast Survey Office	49 04 28	3269.8	3575.7	2.03
			293 02 07	Lunatic Asylum	113 03 30	3446.4	3768.9	2.14
Hunter	38 50 42.01	77 02 04.68	186 20 28	Gravelly	6 20 34	2344.3	2563.6	1.46
			254 01 59	Lunatic Asylum	74 03 28	3568.3	3902.2	2.22
Dangerfield	38 49 41.69	77 02 00.91	229 36 38	Lunatic Asylum	49 38 05	4385.1	4795.4	2.73
			177 12 24	Hunter	357 12 22	1861.9	2036.1	1.16
Mount Vernon Hotel	38 52 25.92	77 00 53.15	218 22 53	Coast Survey Office	38 23 19	1618.0	1769.3	1.01
			59 11 28	Gravelly	239 10 50	1706.1	1865.8	1.06
Gillingham's house, chimney	38 46 34.06	77 04 38.29	196 51 59	Lyon	16 52 11	1578.6	1726.3	0.98
			161 15 12	Worth	341 14 35	4411.6	4824.3	2.74
Johnson's house, chimney	38 47 18.40	77 04 00.24	107 21 32	Lyon	287 21 20	482.0	527.1	0.30
			140 16 39	Worth	320 15 38	3654.5	3996.4	2.27
A. Racker's nouse, west chimney.	38 46 39.90	77 05 37.14	234 40 43	Lyon	54 41 32	2302.1	2517.5	1.43
			189 22 28	Erin	9 22 29	166.4	182.0	0.10
C. Rozier's house, west gable	38 46 28.09	77 00 50.08	201 59 09	Oxon Hill	21 59 37	2894.5	3165.3	1.80
			108 34 19	Lyon	288 32 08	5326.1	5824.5	3.31
Hunting Creek Bridge, flag	38 47 30.09	77 03 06.39	82 58 46	Lyon	262 58 00	1772.8	1938.7	1.10
			123 59 24	Worth	303 57 50	4383.6	4793.7	2.72
Fowl's house, cupola	38 47 43.89	77 05 30.03	290 37 11	Lyon	110 37 55	1823.5	1994.1	1.13
			175 12 30	Worth	355 12 26	2031.4	2221.4	1.26
Square yellow house, cupola	38 49 05.67	77 04 22.74	358 30 02	Lyon	178 30 04	3164.9	3461.1	1.97
			74 30 55	Worth	254 30 08	1860.5	2034.5	1.16

GEOGRAPHICAL POSITIONS—Continued.

Section III.—Alexandria and vicinity.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Alexandria Hotel, tower	38 48 15.72	77 02 14.10	111 17 10 175 24 47	Seminary, new steeple Naval Observat'y, signal	291 15 18 355 24 26	4627.3 9998.8	5060.3 10934.4	2.88 6.21
Alexandria market-house, cupola.	38 48 16.19	77 02 18.20	111 33 56 214 26 59	Seminary, new steeple Lunatic Asylum	291 32 07 34 28 37	4530.5 6642.1	4954.4 7263.6	2.82 4.13
Alexandria, Christ Church	38 48 19.26	77 02 33.83	178 06 47 217 31 29	Naval Observat'y, signal Lunatic Asylum	358 06 39 37 33 17	9863.1 6787.3	10786.0 7422.4	6.13 4.22
Alexandria, St. Mary's Church	38 48 03.33	77 02 20.73	176 27 40 213 01 09	Naval Observat'y, signal. Lunatic Asylum	356 27 23 33 02 48	10368.4 7005.9	11338.6 7661.5	6.44 4.35
Alexandria, Baptist Church	38 48 19.87	77 02 22.04	176 27 19 215 40 27	Naval Observat'y, signal. Lunatic Asylum	356 27 03 35 42 07	9857.6 6602.8	10780.0 7220.7	6.13 4.10
Machine shop, brown cupola	38 48 33.78	77 02 26.31	51 21 16 83 54 01	Lyon Ellsworth	231 20 05 263 53 08	3491.3 2065.7	3818.0 2258.9	2.17 1.28
Coal on northern wharf	38 48 47.74	77 01 53.40	175 35 12 179 52 24	Hunter Gravelly	355 35 05 359 52 24	3533.8 5853.4	3864.5 6401.1	2.20 3.64
Marbury	38 48 53.99	77 01 22.47	163 00 45 147 46 55	Hunter Dangerfield	343 00 19 327 46 31	3482.7 1739.6	3808.6 1902.4	2.16 1.08
Stick	38 49 47.74	77 01 14.07	80 36 55 143 54 07	Dangerfield Hunter	260 36 26 323 53 35	1144.9 2070.8	1252.1 2264.6	0.71 1.29
North draw of Long Bridge, flag-staff.	38 52 55.35	77 01 38.05	12 07 46 318 17 58	Gravelly Lunatic Asylum	192 07 36 138 19 11	1821.9 4192.1	1992.4 4584.4	1.13 2.61
Telegraph pole	38 52 36.16	77 01 51.53	248 26 27 2 47 32	Coast Survey Office Gravelly	68 27 30 182 47 30	2593.1 1191.3	2835.7 1302.7	1.61 0.74
Wharf-house, northwest gable	38 51 27.35	76 59 58.90	174 22 29 65 15 44	Coast Survey Office Hunter	354 22 21 245 14 25	3089.2 3339.3	3378.3 3651.8	1.92 2.07
Anacostia Bridge, flag	38 52 13.03	76 59 09.12	23 43 01 236 21 20	Lunatic Asylum Fort Mahan, flag-staff.	203 42 40 56 23 04	1993.7 4814.5	2180.2 5265.0	1.24 2.99
Poplar Point	38 51 54.20	76 59 51.25	350 15 11 167 46 12	Lunatic Asylum Coast Survey Office	170 15 16 347 45 59	1263.2 2298.8	1381.4 2513.9	0.79 1.43
Arsenal wharf, white pile	38 51 40.15	77 00 51.79	44 26 17 178 39 56	Hunter Mount Vernon Hotel	224 25 31 358 39 55	2510.4 1411.8	2745.3 1543.9	1.56 0.88
Eastern Shore of Maryland and Virginia.								
Ragged Point	37 58 37.37	75 17 36.93	87 08 16 162 03 53	Snead Hardy's Hole Island	267 03 15 342 03 04	12088.0 6311.3	13219.0 6901.8	7.51 3.92
Pope's Bay	38 01 08.11	75 14 40.58	102 17 16 72 14 48	Hardy's Hole Island Snead	282 14 38 252 07 55	6389.9 17196.2	6987.8 18805.3	3.97 10.68
Big Bay Point	38 04 55.96	75 16 58.32	334 26 24 26 58 38	Pope's Bay Hardy's Hole Island	154 27 49 206 57 40	7785.7 6358.5	8514.2 6953.5	4.84 3.95
Green Beach	38 04 49.52	75 11 51.27	91 32 39 31 10 32	Big Bay Point Pope's Bay	271 29 30 211 08 47	7484.8 7976.6	8185.1 8722.9	4.65 4.96
Robbin's Point	38 09 20.85	75 15 50.39	325 07 55 11 27 32	Green Beach Big Bay Point	145 10 23 191 26 50	10192.5 8332.4	11146.2 9112.0	6.33 5.18
Long Point	38 00 11.17	75 21 56.74	234 39 42 294 30 02	Hardy's Hole Island Ragged Point	54 41 33 114 32 38	5383.4 6967.3	5887.[illegible] 7619.2	3.35 4.33
Robbin's Cupola	38 08 54.48	75 16 55.30	0 34 32 315 32 09	Big Bay Point Green Beach	180 34 30 135 35 17	7353.7 10576.9	8041.7 11566.5	4.57 6.57
Hawk's Nest	38 05 08.97	75 12 42.88	86 19 59 149 33 22	Big Bay Point Robbin's Point	266 17 22 329 31 26	6237.3 9008.5	6820.9 9851.4	3.88 5.60
Lonesome House	37 59 26.67	75 16 56.04	226 33 53 146 45 07	Pope's Bay Hardy's Hole Island	46 35 16 326 43 53	4549.5 5363.3	4975.2 5865.1	2.83 3.33
Marsh Point House	37 57 30.25	75 24 53.95	135 58 52 221 03 38	Snead Long Point	315 58 17 41 05 27	2026.1 6581.1	2215.7 7196.9	1.26 4.09
Vicinity of Baltimore, Md.								
ROSANNE	39 17 27.50	76 42 45.84	....	....	....	....	....	....
WASHINGTON MONUMENT	39 17 47.81	76 36 38.58	85 57 41	Rosanne	265 53 48	8821.7	9647.2	5.48
Oak	39 16 15.73	76 40 02.38	119 28 49 239 48 25	Rosanne Washington Monument.	299 27 06 59 50 34	4499.3 5649.1	4920.3 6177.7	2.80 3.51

GEOGRAPHICAL POSITIONS—Continued.

Section III.—Vicinity of Baltimore, Md.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
De Sales	39 17 03.30	76 43 01.13	261 27 05	Washington Monument	81 31 07	9268.6	10135.8	5.76
			288 53 22	Oak	108 55 15	4528.1	4951.8	2.81
Druid	39 19 21.21	76 38 31.70	316 44 17	Washington Monument	136 45 28	3954.3	4324.3	2.46
			56 38 46	De Sales	236 35 56	7729.7	8453.0	4.80
Clifton	39 19 11.74	76 34 56.32	43 26 05	Washington Monument	223 25 00	3563.2	3896.6	2.21
			71 12 52	De Sales	251 07 45	12271.4	13419.6	7.62
Alms, corner of building	39 17 20.30	76 32 50.49	88 00 09	De Sales	267 53 42	14642.1	16012.2	9.10
			98 50 35	Washington Monument	278 48 11	5530.4	6047.8	3.44
Pious Hill	39 20 11.74	76 33 21.95	50 42 10	Clifton	230 41 10	2921.1	3194.4	1.82
			46 43 00	Washington Monument	226 40 56	6471.5	7077.0	4.02
House of Refuge	39 15 47.86	76 43 06.96	241 49 20	Clifton	61 54 31	13331.5	14578.9	8.28
			248 17 26	Washington Monument	68 21 32	10015.6	10952.7	6.22
Mount Alto	39 19 02.93	76 40 14.87	50 52 54	Rosanne	230 51 18	4662.5	5098.7	2.90
			47 12 48	De Sales	227 11 03	5428.8	5936.7	3.37
McDonald's house, cupola	39 20 15.82	76 36 28.58	60 16 45	Druid	240 15 27	3395.0	3712.7	2.11
			311 48 26	Clifton	131 49 24	2964.3	3241.7	1.84
Woodlawn House	39 19 35.14	76 37 35.02	337 46 31	Washington Monument	157 47 07	3575.1	3909.6	2.22
			72 26 39	Druid	252 26 03	1423.6	1556.8	0.88
St. John's Church, spire	39 19 28.25	76 36 14.48	86 14 04	Druid	266 12 37	3293.4	3601.5	2.05
			285 13 01	Clifton	105 13 49	1939.7	2121.2	1.21
Green Mount Cemetery, spire	39 18 22.67	76 36 09.06	117 51 53	Druid	297 50 23	3864.2	4225.8	2.40
			229 01 04	Clifton	49 01 50	2307.5	2523.4	1.43
Baltimore Cemetery, spire	39 18 41.96	76 34 33.25	148 56 29	Clifton	328 56 14	1071.9	1172.2	0.67
			315 38 30	Alms	135 39 35	3521.3	3850.8	2.19
Hospital	39 17 47.07	76 35 12.63	283 36 58	Alms	103 38 28	3504.2	3832.1	2.18
			90 39 13	Washington Monument	270 38 19	2059.4	2252.1	1.28
Fort Marshall, flagstaff	39 17 04.22	76 33 47.27	185 58 58	Pious Hill	5 59 14	5814.2	6358.2	3.61
			157 11 14	Clifton	337 10 30	4266.1	4665.3	2.65
Fort McHenry, flagstaff, 1866	39 15 44.21	76 34 28.12	140 38 53	Washington Monument	320 37 31	4929.4	5390.7	3.06
			173 58 26	Clifton	353 58 08	6434.9	7037.1	4.00
Patapsco River, Md.								
NORTH POINT, UPPER LIGHT	39 11 46.02	76 26 35.88	343 15 10	Bodkin	163 16 04	7217.0	7892.3	4.48
NORTH POINT, LOWER LIGHT	39 11 35.87	76 26 12.49	347 02 32	Bodkin	167 03 11	6770.6	7404.2	4.21
Rock Point, 1866	39 09 58.72	76 28 24.16	218 07 26	North Point, upper light	38 08 34	4207.3	4601.0	2.61
			226 29 43	North Point, lower light	46 31 06	4354.1	4761.5	2.71
Seven Feet Knoll light	39 09 16.07	76 24 14.36	146 40 30	North Point, lower light	326 39 16	5160.0	5642.8	3.21
			102 23 13	Rock Point, 1866	282 20 35	6138.0	6712.3	3.81
Sparrow Point, 1866	39 12 38.02	76 29 07.41	294 31 13	North Point, lower light	114 33 03	4611.9	5043.5	2.87
			293 47 03	North Point, upper light	113 48 38	3972.5	4344.2	2.47
Swan Point, 1866	39 08 28.85	76 16 29.35	112 26 34	North Point, lower light	292 20 26	15138.9	16555.4	9.41
			112 43 09	North Point, upper light	292 36 46	15776.6	17252.8	9.80
Sandy Point Light	39 01 07.52	76 23 28.77	167 09 13	North Point, upper light	347 07 15	20195.0	22084.6	12.55
			169 18 19	Bodkin	349 17 16	13003.5	14220.2	8.08
Gibson's Island, 1866	39 04 36.53	76 25 09.35	180 00 59	Bodkin	0 00 59	6332.2	6924.7	3.93
			240 07 16	Swan Point, 1866	60 12 44	14399.8	15747.2	8.95
Hawkins Point, 1866	39 12 31.96	76 31 41.09	267 04 30	Sparrow Point, 1866	87 06 07	3690.4	4035.7	2.29
			314 58 47	Rock Point, 1866	135 00 51	6681.7	7306.9	4.15
Fort Carroll light	39 12 49.67	76 30 50.21	278 16 11	Sparrow Point, 1866	98 17 16	2491.3	2724.4	1.55
			326 22 10	Rock Point, 1866	146 23 42	6329.2	6921.5	3.93
Sollers Point	39 13 36.68	76 30 30.37	312 16 00	Sparrow Point, 1866	132 16 53	2688.3	2939.9	1.67
			40 21 44	Hawkins Point, 1866	220 21 00	2620.9	2866.2	1.63
Fishing Point	39 13 47.50	76 33 30.38	274 23 44	Sollers Point	94 25 38	4329.0	4734.0	2.69
			311 36 51	Hawkins Point, 1866	131 38 00	3506.0	3834.1	2.18
Front Range light	39 12 25.10	76 31 39.50	170 12 33	Hawkins Point, 1866	350 12 32	213.2	233.1	0.13
			133 42 09	Fishing Point	313 40 59	3675.4	4019.3	2.28
Back Range light	39 12 46.01	76 32 48.99	284 55 40	Hawkins Point, 1866	104 56 23	1687.6	1845.5	1.05
			244 50 54	Sollers Point	64 52 22	3674.4	4018.2	2.28
Buchanan	39 15 26.60	76 32 20.48	350 02 51	Hawkins Point, 1866	170 03 16	5467.1	5978.7	3.40
			322 04 32	Sollers Point	142 05 42	4296.0	4698.0	2.67

GEOGRAPHICAL POSITIONS—Continued.

Section III.—Patapsco River, Md.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Alms House, cupola	39 17 20.08	76 32 47.97	349 45 52	Hawkins Point, 1866	169 46 34	9027.3	9872.0	5.61
			8 49 01	Fishing Point	188 48 34	6633.3	7254.0	4.12
White house, center	39 06 02.35	76 25 31.60	250 49 26	Swan Point, 1866	70 55 08	13785.2	15075.1	8.57
			188 16 20	Bodkin	8 16 34	3724.6	4073.1	2.31
Solitary tree	39 07 04.53	76 25 40.00	202 38 10	Bodkin	22 38 29	1916.4	2095.7	1.19
			258 49 40	Swan Point, 1866	78 55 28	13477.4	14738.5	8.37
Large tree	39 08 04.31	76 26 05.41	173 53 53	North Point, upper light	353 53 34	6875.6	7518.9	4.27
			178 30 04	North Point, lower light	358 30 00	6526.5	7137.2	4.05
Straight tree	39 08 28.56	76 26 40.24	180 58 53	North Point, upper light	0 58 56	6090.0	6659.8	3.78
			186 34 06	North Point, lower light	6 34 23	5814.5	6358.5	3.61
White House, largest chimney	39 07 30.07	76 25 44.49	174 55 22	North Point, lower light	354 55 04	7609.6	8321.6	4.73
			171 07 45	North Point, upper light	351 07 13	7988.4	8735.9	4.96
Large unpainted house, southwest chimney.	39 12 38.32	76 26 52.39	346 12 21	North Point, upper light	166 12 31	1660.0	1815.3	1.03
			24 06 45	Rock Point, 1866	204 05 47	5391.5	5895.9	3.35
House at Rock Creek, north end	39 09 13.27	76 29 15.96	219 10 47	North Point, upper light	39 12 28	6078.6	6647.4	3.78
			225 00 26	North Point, lower light	45 02 22	6230.0	6812.9	3.87
House with window near top, southwest gable.	39 14 21.23	76 30 27.85	76 38 09	Fishing Point	256 36 14	4497.1	4917.9	2.79
			27 31 12	Hawkins Point, 1866	207 30 26	3799.1	4154.6	2.36
Hancock's House, chimney	39 09 42.38	76 28 39.05	301 34 56	Bodkin	121 37 08	5911.5	6464.6	3.67
			217 46 12	North Point, upper light	37 47 30	4824.3	5275.7	3.00
Two-story white house, with green blinds, chimney.	39 10 41.65	76 31 30.74	257 36 23	North Point, lower light	77 39 44	7816.2	8547.6	4.86
			254 17 25	North Point, upper light	74 20 31	7347.9	8035.4	4.57
Two-story unpainted house, north chimney.	39 11 15.45	76 31 43.27	265 25 19	North Point, lower light	85 28 48	7962.7	8707.8	4.95
			262 40 25	North Point, upper light	82 43 39	7435.9	8131.7	4.62
Bird nest tree	39 12 47.40	76 28 17.50	307 48 39	North Point, upper light	127 49 43	3085.6	3374.3	1.92
			1 45 35	Rock Point, 1866	181 45 31	5203.8	5690.8	3.23
House on Sparrow Point, cupola	39 12 58.97	76 29 13.91	347 52 37	Rock Point, 1866	167 53 08	5684.5	6216.4	3.53
			346 25 57	Hawkins Point, 1866	166 26 01	664.8	727.0	0.41
New shed, west end	39 14 58.36	76 31 17.79	7 03 03	Hawkins Point, 1866	187 02 48	4549.0	4974.6	2.83
			120 05 18	Buchanan	300 04 38	1736.7	1899.2	1.08
Blazed tree	39 12 31.50	76 31 39.85	115 47 26	Hawkins Point, 1866	295 47 25	32.9	36.0	0.02
Red Range mark	39 12 31.28	76 31 59.97	312 13 55	Rock Point, 1866	132 16 11	6995.0	7649.5	4.35
			267 18 07	Hawkins Point, 1866	87 18 19	453.5	495.9	0.28
White Range mark	39 12 26.54	76 31 44.10	313 30 50	Rock Point, 1866	133 32 56	6616.7	7235.8	4.11
			203 19 32	Hawkins Point, 1866	23 19 34	182.1	199.1	0.11
Robinson's house, chimney	39 12 38.97	76 33 07.64	192 20 11	Buchanan	12 20 41	5291.5	5786.6	3.29
			165 31 54	Fishing Point	345 31 40	2182.2	2386.4	1.36
J. L. Sutton's house, with flat roof, southeast chimney.	39 15 42.11	76 31 43.81	61 27 13	Buchanan	241 26 50	1002.5	1096.3	0.62
			35 51 48	Fishing Point	215 50 41	4361.3	4769.4	2.71
J. L. Sutton's large brick house, southeast chimney.	39 15 30.71	76 31 35.92	83 14 31	Buchanan	263 14 03	1075.5	1176.1	0.67
			40 46 20	Fishing Point	220 45 08	4202.3	4595.5	2.61
White barn, cupola	39 15 31.66	76 31 37.58	0 52 04	Hawkins Point, 1866	180 52 02	5541.5	6060.0	3.44
			81 22 55	Buchanan	261 22 28	1039.8	1137.1	0.65
Old Canton House, south chimney.	39 15 38.37	76 32 51.94	15 05 09	Fishing Point	195 04 45	3540.6	3871.9	2.20
			295 40 31	Buchanan	115 40 51	836.6	914.9	0.52
Mrs. Wood's house, chimney	39 15 39.62	76 32 48.78	16 05 29	Fishing Point	196 05 03	3598.2	3934.9	2.24
			300 36 56	Buchanan	120 36 38	788.0	861.7	0.49
Bonell's house, chimney	39 15 37.45	76 32 35.89	312 15 35	Buchanan	132 15 45	498.6	545.2	0.31
			321 02 29	Sollers Point	141 03 48	4787.2	5235.2	2.97
Graves' house, west chimney	39 15 35.75	76 32 12.80	326 12 33	Sollers Point	146 13 38	4416.7	4829.9	2.74
			29 07 32	Fishing Point	209 06 43	3821.3	4178.8	2.37
Graves' barn, west gable	39 15 33.61	76 32 13.90	325 26 33	Sollers Point	145 27 38	4377.1	4786.7	2.72
			29 15 46	Fishing Point	209 14 58	3750.8	4101.8	2.33
Lazaretto Furnace, cupola	39 15 40.34	76 33 49.80	308 32 56	Sollers Point	128 35 02	6114.6	6686.7	3.80
			281 10 12	Buchanan	101 11 08	2182.2	2386.4	1.36
R. O. Crisp's two-story white house, chimney.	39 13 35.52	76 34 02.51	244 22 16	Fishing Point	64 22 36	854.9	934.9	0.53
			299 59 53	Hawkins Point, 1866	120 01 23	3916.9	4283.4	2.43
R. O. Crisp's barn, east gable	39 13 35.67	76 33 59.26	242 13 18	Fishing Point	62 13 36	782.9	856.2	0.49
			300 38 31	Hawkins Point, 1866	120 39 58	3852.0	4212.4	2.39

GEOGRAPHICAL POSITIONS—Continued.

Section III.—Patapsco River, Md.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Yards.*	*Meters.*	*Miles.*
Lazaretto light	39 15 42.45	76 33 59.21	307 44 10	Sollers Point	127 46 22	6332.4	6924.9	3.93
			348 57 32	Fishing Point	168 57 50	3611.0	3948.9	2.24
Red barn with door in end, south gable.	39 15 45.63	76 33 34.60	311 58 31	Sollers Point	132 00 28	5942.2	6498.2	3.69
			358 24 25	Fishing Point	178 24 28	3643.9	3984.9	2.26
Brown barn, south gable	39 15 48.19	76 33 31.00	313 05 58	Sollers Point	133 07 52	5932.2	6487.3	3.69
			359 45 55	Fishing Point	179 45 55	3721.5	4069.7	2.31
House on Snow Hill, chimney	39 12 20.49	76 35 09.66	221 34 45	Fishing Point	41 35 48	3587.4	3923.1	2.23
			215 14 17	Buchanan	35 16 04	7028.3	7686.0	4.37
G. Crisp's large house with dormer-window, west chimney.	39 14 10.72	76 34 26.16	280 29 21	Sollers Point	100 31 50	5750.3	6288.3	3.57
			307 33 00	Hawkins Point, 1866	127 34 44	4994.1	5461.4	3.10
Walker's unpainted house, northwest chimney.	39 13 02.66	76 34 03.91	209 10 31	Buchanan	29 11 36	5084.2	5559.9	3.16
			210 12 17	Fishing Point	30 12 38	1600.2	1749.9	0.99
Marine hospital, flag-staff	39 14 37.25	76 34 29.83	287 59 17	Sollers Point	108 01 48	6037.4	6602.3	3.75
			313 39 22	Hawkins Point, 1866	133 41 09	5593.8	6117.2	3.48

Section IV.—Roanoke River, N. C.

WILLIAMS	35 56 07.54	76 38 00.32						
EDENTON COURT-HOUSE	36 03 23.77	76 36 11.06	11 30 48	Williams	191 29 44	13719.6	15003.3	8.52
Major	35 56 40.67	76 41 21.35	281 26 23	Williams	101 28 21	5140.4	5621.3	3.19
			211 59 59	Edenton Court-House	32 03 01	14652.9	16024.0	9.10
New Capeheart	35 58 55.52	76 40 52.21	9 57 53	Major	189 57 36	4219.6	4614.4	2.62
			320 13 42	Williams	140 15 23	6734.2	7364.3	4.18
Eastmost	35 56 47.75	76 42 06.21	280 58 43	Major	100 59 09	1145.3	1252.5	0.71
			205 12 25	New Capeheart	25 13 08	4352.4	4759.6	2.70
Hardy	35 58 25.02	76 42 30.05	348 43 54	Eastmost	168 44 08	3056.7	3342.7	1.90
			331 50 12	Major	151 50 52	3647.7	3989.0	2 27
Maple	35 56 19.58	76 42 39.68	224 00 28	Eastmost	44 00 48	1207.0	1320.0	0.75
			183 34 13	Hardy	3 34 19	3873.4	4235.8	2.41
Cashai	35 56 28.06	76 43 15.11	286 23 59	Maple	106 24 20	925.7	1012.3	0.57
			250 38 04	Eastmost	70 38 44	1830.2	2001.4	1.14
Middle	35 56 00.31	76 43 41.57	249 02 20	Maple	69 02 56	1661.1	1816.5	1.03
			217 46 38	Cashai	37 46 53	1082.4	1183.7	0.67
Bayou	35 56 12.05	76 43 52.64	322 31 27	Middle	142 31 34	455.9	498.6	0.28
			262 45 19	Maple	82 46 02	1843.3	2015.8	1.15
Doten	35 56 32.77	76 41 33.60	231 35 48	Major	51 35 55	391.9	428.6	0.24
			119 27 42	Eastmost	299 27 23	938.6	1026.4	0.58
Louse	35 56 18.38	76 41 25.20	187 59 48	Major	7 59 50	693.8	758.8	0.43
			154 36 33	Doten	334 36 28	491.1	537.0	0.31
Fuller	35 56 24.27	76 41 32.96	313 01 29	Louse	133 01 34	266.2	291.1	0.17
			209 56 19	Major	29 56 26	583.3	637.9	0.36
Kite	35 56 01.13	76 41 26.48	183 27 07	Louse	3 27 08	532.5	582.3	0.33
			167 09 41	Fuller	347 09 37	731.4	799.8	0.45
King	35 55 57.29	76 41 37.05	245 56 31	Kite	65 56 37	290.3	317.4	0.18
			204 34 15	Louse	24 34 22	714.6	781.4	0.44
Lawrence	35 55 53.74	76 41 26.48	180 01 25	Kite	0 01 25	227.6	248.9	0.14
			112 24 45	King	292 24 39	286.6	313.4	0.18
Brown	35 55 35.23	76 41 39.86	210 26 21	Lawrence	30 26 29	661.8	723.8	0.41
			185 54 10	King	5 54 12	683.5	747.4	0.42
Lewis	35 55 36.95	76 41 48.29	284 07 39	Brown	104 07 44	218.1	238.5	0.14
			226 34 52	Lawrence	46 35 05	752.7	823.2	0.47
Ice	35 55 16.60	76 41 49.41	202 38 55	Brown	22 39 01	621.9	680.1	0.39
			182 33 20	Lewis	2 33 21	627.8	686.5	0.39
Wiley	35 55 22.28	76 41 53.92	327 09 19	Ice	147 09 22	208.2	227.7	0.13
			221 27 05	Brown	41 27 13	532.3	582.1	0.33
Tompkins	35 55 18.73	76 42 12.42	276 29 03	Ice	96 29 16	580.6	635.0	0.36
			256 44 16	Wiley	76 44 27	476.7	521.3	0.30
Fire	35 55 23.33	76 42 16.72	322 46 43	Tompkins	142 46 46	178.1	194.8	0.11
			286 51 06	Ice	106 51 22	715.4	782.3	0.44

GEOGRAPHICAL POSITIONS—Continued.

Section IV.— Roanoke River, N. C.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Cross	35 55 18.07	76 42 32.96	267 44 19	Tompkins	87 44 31	515.2	563.4	0.32
			248 16 54	Fire	68 17 03	438.2	479.2	0.27
Pip	35 55 12.79	76 42 31.03	227 48 03	Fire	47 48 11	484.0	529.3	0.30
			163 25 06	Cross	343 25 05	170.0	185.9	0.11
Island	35 55 04.81	76 42 45.77	236 22 37	Pip	56 22 46	443.8	485.4	0.28
			218 08 50	Cross	38 08 58	519.7	568.3	0.32
Eagle	35 55 07.47	76 42 51.04	301 42 32	Island	121 42 35	155.5	170.0	0.10
			251 54 07	Pip	71 54 19	527.9	577.3	0.33
Cane	35 54 49.56	76 43 06.92	228 26 42	Island	48 26 54	708.6	774.9	0.44
			215 48 04	Eagle	35 48 13	680.3	743.9	0.42
Raccoon	35 54 55.53	76 42 55.97	198 34 15	Eagle	18 34 18	388.1	424.5	0.24
			56 10 34	Cane	236 10 28	330.2	361.1	0.21
Buzzard	35 54 38.73	76 43 06.75	207 33 11	Raccoon	27 33 17	583.8	638.5	0.36
			179 15 57	Cane	359 15 57	333.8	365.1	0.21
Lower	35 54 41.59	76 43 17.11	288 43 53	Buzzard	108 43 59	274.4	300.1	0.17
			226 07 44	Cane	46 07 50	354.5	387.6	0.22
Harris	35 54 28.69	76 43 20.78	228 40 06	Buzzard	48 40 14	468.6	512.4	0.29
			193 02 08	Lower	13 02 10	408.1	446.3	0.25
Bald	35 54 22.22	76 43 07.26	157 32 05	Lower	337 31 59	646.0	706.5	0.40
			120 27 54	Harris	300 27 46	393.2	430.0	0.24
Rattan	35 54 05.34	76 43 12.94	195 18 09	Bald	15 18 12	539.3	589.8	0.34
			164 43 13	Harris	344 43 08	745.9	815.7	0.46
Philip	35 54 08.61	76 43 28.10	284 49 37	Rattan	104 49 46	393.2	430.0	0.24
			231 13 56	Bald	51 14 08	670.1	732.8	0.42
Fish-house	35 53 47.14	76 43 36.42	226 22 47	Rattan	46 23 01	813.1	889.2	0.51
			197 29 26	Philip	17 29 31	693.6	758.5	0.43
Gum tree	35 53 36.28	76 43 28.09	179 59 15	Philip	359 59 15	996.3	1089.5	0.62
			148 03 44	Fish-house	328 03 39	394.5	431.4	0.25
Scow	35 53 17.90	76 43 33.47	193 22 55	Gum tree	13 22 58	582.2	636.7	0.36
			175 18 29	Fish-house	355 18 27	904.2	988.8	0.56
Moss	35 53 22.89	76 43 44.60	298 50 54	Scow	118 51 01	318.7	348.5	0.20
			225 05 11	Gum tree	45 05 21	584.4	639.1	0.36
Mac	35 52 52.79	76 43 49.50	207 27 40	Scow	27 27 49	872.1	953.7	0.54
			187 33 14	Moss	7 33 17	935.7	1023.2	0.58
Barber	35 52 56.37	76 43 56.96	300 32 53	Mac	120 32 57	217.3	237.6	0.14
			221 36 56	Scow	41 37 10	887.3	970.3	0.55
Norcome	35 52 39.59	76 43 55.68	200 51 16	Mac	20 51 20	435.4	476.1	0.27
			176 26 32	Barber	356 26 31	518.3	566.8	0.32
Sheep	35 52 44.02	76 44 03.89	303 33 03	Norcome	123 33 08	247.1	270.3	0.15
			233 09 57	Mac	53 10 05	450.9	493.1	0.28
North base	35 52 23.98	76 44 08.06	212 49 27	Norcome	32 49 34	572.6	626.1	0.36
			189 36 01	Sheep	9 36 03	626.5	685.1	0.39
Prizeboats	35 52 33.06	76 44 11.38	343 25 00	North base	163 25 02	292.2	319.5	0.18
			242 56 25	Norcome	62 56 34	442.2	483.6	0.27
South base	35 52 43.18	76 44 19.68	221 12 36	North base	41 12 43	442.5	483.9	0.27
			198 45 18	Prizeboats	18 45 23	647.2	707.8	0.40
Catfish	35 52 16.90	76 44 29.05	296 02 57	South base	116 03 02	261.7	286.2	0.16
			247 31 00	North base	67 31 12	569.9	623.2	0.35
Wharf	35 51 56.93	76 44 49.88	236 32 11	South base	56 32 29	908.0	992.9	0.56
			220 19 01	Catfish	40 19 13	807.4	883.0	0.50
Miami	35 52 01.52	76 44 57.92	305 03 09	Wharf	125 03 14	246.4	269.5	0.15
			249 28 09	South base	69 28 31	1024.2	1120.0	0.64
Wards	35 51 49.51	76 45 15.35	250 19 15	Wharf	70 19 30	678.6	742.1	0.42
			229 45 51	Miami	49 46 01	572.8	626.4	0.36
Briar	35 51 54.23	76 45 19.90	321 54 01	Wards	141 54 04	184.7	201.9	0.11
			263 41 48	Wharf	83 42 06	757.5	828.4	0.47
Southfield	35 51 43.56	76 45 48.20	257 27 08	Wards	77 27 27	844.2	923.2	0.52
			245 09 20	Briar	65 09 37	782.5	855.7	0.49
Whitehead	35 51 48.88	76 45 47.62	5 06 36	Southfield	185 06 36	164.6	180.0	0.10
			268 37 12	Wards	88 37 31	809.6	885.4	0.50

GEOGRAPHICAL POSITIONS—Continued.

Section IV.—Roanoke River, N. C.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Distance
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
East base	35 51 39.61	76 46 15.39	259 52 04	Southfield	79 52 20	692.8	757.7	0.43
			247 41 41	Whitehead	67 41 57	753.0	823.5	0.47
Cypress	35 51 52.90	76 46 15.12	0 56 00	East base	180 56 00	409.7	448.0	0.25
			293 04 39	Southfield	113 04 55	734.1	802.8	0.46
West base	35 51 42.98	76 46 31.40	284 29 08	East base	104 29 17	414.8	453.6	0.26
			233 09 36	Cypress	53 09 45	510.1	557.8	0.32
Path	35 52 02.42	76 46 37.17	346 24 52	West base	166 24 55	616.4	674.1	0.38
			322 08 19	East base	142 08 32	890.2	973.5	0.55
Hut	35 51 52.57	76 46 50.58	301 33 01	West base	121 33 12	564.7	617.5	0.35
			227 56 07	Path	47 56 15	453.2	495.6	0.28
War Neck	35 52 05.55	76 47 11.11	307 50 42	Hut	127 50 54	652.1	713.1	0.41
			276 27 40	Path	96 28 00	856.8	936.9	0.53
Nicols	35 52 15.97	76 47 07.25	16 46 29	War Neck	196 46 27	335.3	366.7	0.21
			329 53 34	Hut	149 53 44	833.6	911.6	0.52
No Woods	35 52 22.04	76 47 33.36	312 19 36	War Neck	132 19 49	754.9	825.6	0.47
			285 57 23	Nicols	105 57 38	681.1	744.8	0.42
Target	35 52 25.79	76 47 24.73	61 55 29	No Woods	241 55 24	245.2	268.2	0.15
			331 16 49	War Neck	151 16 57	711.2	777.7	0.44
Duck Point	35 52 40.14	76 47 46.51	329 23 24	No Woods	149 23 32	648.1	708.8	0.40
			308 59 53	Target	129 00 06	703.0	768.8	0.44
Redberry	35 52 50.20	76 47 43.14	15 17 10	Duck Point	195 17 08	321.3	351.3	0.20
			344 12 50	No Woods	164 12 56	901.7	986.1	0.56
Wild Cat	35 53 07.01	76 48 09.31	325 22 28	Duck Point	145 22 41	1006.3	1100.5	0.63
			308 17 09	Redberry	128 17 24	836.3	914.6	0.52
Shell	35 52 55.58	76 48 05.93	286 11 02	Redberry	106 11 15	595.2	650.9	0.37
			166 27 45	Wild Cat	346 27 43	362.4	396.3	0.23
Ryan	35 53 11.24	76 48 37.73	301 10 39	Shell	121 10 58	932.4	1019.6	0.58
			280 21 59	Wild Cat	100 22 16	724.7	792.5	0.45
Vicinity of Roanoke Island.								
Roanoke Marshes light-house	35 48 36.41	75 41 46.90	220 27 25	Baum's Creek	40 28 40	4928.7	5389.9	3.06
			137 59 14	Callaghan's Creek	317 57 51	5301.6	5797.6	3.29
Pork Point, 1864	35 54 01.09	75 41 36.85	32 01 37	Callaghan's Creek	212 00 08	7161.1	7831.2	4.45
			65 40 11	Fleetwood	245 38 27	4897.2	5355.5	3.04
Fulker's Island	33 51 54.04	75 41 02.12	167 27 46	Pork Point, 1864	347 27 26	4011.1	4386.4	2.49
			109 35 34	Fleetwood	289 33 29	5660.9	6190.6	3.52
Croatan light-house	35 57 34.97	75 47 23.37	333 50 31	Fleetwood	153 52 10	9591.5	10488.9	5.96
			307 10 01	Pork Point, 1864	127 13 24	10903.3	11923.5	6.77
Neuse River, N. C.								
Spinola, 2	35 05 16.50	77 01 31.32						
Rebel fort	35 04 38.61	77 00 42.66	133 27 08	Spinola, 2	313 26 40	1697.7	1856.5	1.06
Duck Creek	35 05 23.53	77 00 07.17	84 12 26	Spinola, 2	264 11 38	2142.4	2342.8	1.33
			33 00 41	Rebel fort	213 00 20	1650.3	1804.7	1.03
Spinola	35 05 10.47	77 01 30.59	259 12 44	Duck Creek	79 13 32	2150.9	2352.2	1.34
			308 57 09	Rebel fort	128 57 36	1561.3	1707.4	0.97
Truck	35 04 23.61	77 01 33.29	182 42 34	Spinola	2 42 36	1445.5	1580.7	0.90
			250 10 30	Rebel fort	70 10 59	1363.3	1490.8	0.85
New Berne base, north end	35 05 06.37	77 02 16.68	263 49 15	Spinola	83 49 42	1174.1	1284.0	0.73
			320 09 47	Truck	140 10 12	1715.8	1876.3	1.07
New Berne base, south end	35 04 24.00	77 02 52.66	214 55 08	North base	34 55 29	1592.1	1741.1	0.99
			270 20 25	Truck	90 21 10	2010.6	2198.8	1.25
Prince	35 06 04.29	77 00 51.78	354 59 59	Rebel fort	175 00 05	2650.2	2898.2	1.65
			318 01 30	Duck Creek	138 01 56	1689.5	1847.6	1.05
New Berne Episcopal church, brown spire.	35 06 20.38	77 02 02.87	339 13 07	Spinola	159 13 26	2304.2	2519.8	1.43
			8 43 08	North base	188 43 00	2307.3	2523.1	1.43
Foster	35 07 22.05	77 01 19.14	343 52 26	Prince	163 52 42	2494.2	2727.6	1.55
			30 14 06	Episcopal church spire	210 13 41	2199.2	2405.0	1.37
Palmer	35 07 25.21	77 02 41.90	272 39 24	Foster	92 40 12	2097.6	2293.9	1.30
			333 40 27	Episcopal church spire	153 40 49	2228.7	2437.2	1.38

GEOGRAPHICAL POSITIONS—Continued.

Section IV.—Neuse River, N. C.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Fort Totten, flag-staff	35 06 23.98	77 03 10.30	310 57 27	Rebel fort	130 58 52	4952.1	5415.5	3.08
			311 53 17	Spinola	131 54 14	3392.2	3709.6	2.11
Lone pine tree	35 04 45.25	77 01 41.61	70 00 44	South base	250 00 03	1915.1	2094.3	1.19
			126 13 37	North base	306 13 17	1101.0	1204.0	0.68
North blockade	35 04 30.25	76 59 35.72	98 38 36	Rebel fort	278 37 58	1715.1	1875.6	1.07
			154 07 10	Duck Creek	334 06 52	1824.6	1995.3	1.13
South blockade	35 03 41.26	77 00 12.37	156 31 34	Rebel fort	336 31 17	1926.6	2106.9	1.20
			211 35 22	North blockade	31 35 43	1772.1	1937.9	1.10
Wessel	35 03 51.77	76 58 59.51	142 16 30	North blockade	322 16 09	1499.2	1639.5	0.93
			118 55 20	Rebel fort	298 54 21	2985.3	3264.6	1.85
Burnside	35 03 11.73	76 59 37.01	148 09 11	Rebel fort	328 08 34	3151.9	3446.8	1.96
			217 35 33	Wessel	37 35 54	1557.3	1703.0	0.97
Mast of sunken schooner	35 04 07.64	77 00 05.98	227 44 15	North blockade	47 44 32	1035.7	1132.6	0.64
			286 11 30	Wessel	106 12 08	1753.7	1917.7	1.09
Upper Northwest Creek	35 03 19.48	76 57 54.96	84 43 31	Burnside	264 42 32	2596.5	2839.4	1.61
			121 19 11	Wessel	301 18 34	1914.1	2093.2	1.19
Johnson's Point	35 02 31.32	76 58 59.89	142 56 29	Burnside	322 56 08	1560.3	1706.3	0.97
			227 56 34	Upper N. W. Creek	47 57 11	2215.8	2423.1	1.38
Upper Broad Creek	35 01 59.02	76 55 48.14	101 35 27	Johnson's Point	281 33 37	4960.4	5424.5	3.08
			127 39 43	Upper N. W. Creek	307 38 30	4059.1	4439.0	2.52
Mitchell's Bluff	35 00 42.10	76 58 34.21	191 35 17	Upper N. W. Creek	11 35 39	4950.7	5414.0	3.08
			240 36 16	Upper Broad Creek	60 37 51	4830.9	5282.9	3.00
Marsh	34 59 14.93	76 56 52.21	151 52 05	Johnson's Point	331 50 52	6862.7	7504.9	4.26
			136 05 24	Mitchell's Bluff	316 04 25	3728.6	4077.5	2.32
Lower Northwest Creek	35 02 45.26	76 56 34.25	38 42 32	Mitchell's Bluff	218 41 23	4862.8	5317.8	3.02
			320 38 29	Upper Broad Creek	140 38 55	1842.8	2015.3	1.15
Goose Creek	35 01 59.15	76 55 48.29	101 33 07	Johnson's Point	281 31 17	4956.0	5419.8	3.08
			60 33 57	Mitchell's Bluff	240 32 22	4829.6	5281.5	3.00
Beard's Creek	35 00 12.67	76 52 20.90	75 31 22	Marsh	255 28 46	7105.7	7770.5	4.42
			121 59 10	Goose Creek	301 57 11	6197.1	6777.0	3.85
Slocum's Creek	34 57 24.53	76 53 30.11	198 42 38	Beard's Creek	18 43 18	5470.0	5981.8	3.40
			157 31 06	Goose Creek	337 29 47	9158.7	10015.7	5.69
Reed	34 56 46.78	76 51 42.50	171 16 30	Beard's Creek	351 16 08	6418.6	7019.2	3.99
			113 05 25	Slocum's Creek	293 04 23	2967.7	3245.4	1.84
Alligator	34 58 12.64	76 48 56.69	77 57 29	Slocum's Creek	257 54 52	7092.0	7755.6	4.41
			57 50 32	Reed	237 48 57	4969.0	5433.9	3.09
Wilkinson's Point	34 57 50.24	76 47 55.35	71 16 24	Reed	251 14 14	6085.1	6654.5	3.78
			84 41 53	Slocum's Creek	264 38 41	8528.5	9326.5	5.30
Cherry Point	34 56 16.61	76 48 20.82	100 18 43	Reed	280 16 48	5201.0	5687.7	3.23
			104 57 34	Slocum's Creek	284 54 37	8121.4	8881.3	5.05
Dana	34 58 01.74	76 54 57.06	169 56 09	Goose Creek	349 55 40	7429.9	8125.1	4.62
			224 27 22	Beard's Creek	44 28 52	5653.2	6182.2	3.51
Benner	34 59 11.61	76 50 19.58	55 41 31	Slocum's Creek	235 39 42	5851.3	6398.8	3.64
			25 14 19	Reed	205 13 31	4933.7	5395.3	3.07
Red Bank	34 56 05.58	76 50 17.31	207 34 26	Alligator	27 35 12	4417.1	4830.4	2.75
			228 08 46	Wilkinson's Point	48 10 07	4834.3	5286.6	3.00
Pierson's Point	34 58 30.68	76 46 00.30	40 48 03	Cherry Point	220 46 42	5456.5	5967.1	3.39
			66 53 10	Wilkinson's Point	246 52 04	3173.2	3470.1	1.97
Great Island	34 55 44.43	76 44 30.92	99 39 53	Cherry Point	279 37 41	5917.3	6471.0	3.68
			126 47 28	Wilkinson's Point	306 45 31	6475.3	7081.2	4.02
Great Neck Point	34 57 12.71	76 42 06.02	112 01 52	Pierson's Point	291 59 38	6410.0	7009.8	3.98
			53 30 52	Great Island	233 29 29	4573.5	5001.4	2.84
Sand Beach	35 00 12.03	76 42 27.96	20 43 46	Great Island	200 42 35	8815.6	9640.5	5.48
			354 14 51	Great Neck Point	174 15 04	5553.3	6072.9	3.45
Cedar Point	34 58 51.43	76 39 13.77	116 46 50	Sand Beach	296 44 59	5515.0	6031.1	3.43
			55 10 04	Great Neck Point	235 08 26	5323.7	5821.8	3.31
Cockle Point	35 02 51.90	76 38 15.14	11 20 51	Cedar Point	191 20 17	7557.6	8264.8	4.70
			52 28 08	Sand Beach	232 25 43	8083.1	8839.4	5.02
Sandy Point	34 59 15.36	76 37 31.64	103 06 26	Sand Beach	283 03 36	7713.8	8435.6	4.79
			170 37 12	Cockle Point	350 36 47	6763.1	7395.9	4.20

GEOGRAPHICAL POSITIONS—Continued.

Section IV.—Neuse River, N. C.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Brown's Creek	35 00 01.82	76 32 51.28	91 16 42	Sand Beach	271 11 11	14624.6	15993.0	9.09
			78 38 10	Sandy Point	258 35 29	7251.6	7930.1	4.51
Neuse River light	35 05 15.69	76 32 36.39	33 59 59	Sandy Point	213 57 09	13389.3	14642.2	8.32
			2 14 13	Brown's Creek	182 14 04	9679.2	10584.9	6.01
Point of Marsh	35 03 57.76	76 28 09.88	109 36 14	Neuse River Light	289 33 41	7165.2	7835.7	4.45
			82 30 37	Cockle Point	262 24 49	15469.1	16916.6	9.61
Great Marsh	34 55 23.58	76 46 23.10	152 37 28	Wilkinson's Point	332 36 35	5089.2	5565.4	3.16
			257 16 49	Great Island	77 17 53	2918.5	3191.6	1.81
Wm. Nelson's house, chimney	34 59 40.57	76 44 10.82	325 11 57	Great Neck Point	145 13 08	5547.8	6066.9	3.45
			4 00 45	Great Island	184 00 33	7293.7	7976.1	4.53
Hammock	34 58 07.64	76 40 14.71	138 36 52	Sand Beach	318 35 36	5109.4	5587.5	3.17
			59 03 42	Great Neck Point	239 02 38	3291.8	3599.8	2.05
Windmill	35 00 47.49	76 41 52.96	2 51 56	Great Neck Point	182 51 49	6626.4	7246.4	4.12
			311 31 38	Cedar Point	131 33 09	5393.2	5897.8	3.35
Whittaker	35 01 54.64	76 39 45.75	52 27 18	Sand Beach	232 25 45	5186.6	5671.9	3.22
			232 27 37	Cockle Point	52 28 29	2896.5	3167.5	1.80
Two-story house, south chimney	35 01 34.19	76 40 54.45	333 00 42	Cedar Point	153 01 40	5627.7	6154.3	3.50
			309 44 26	Sandy Point	129 46 22	6689.4	7315.3	4.16
Gum Thicket	35 04 03.52	76 35 54.42	328 03 01	Brown's Creek	148 04 46	8776.2	9597.4	5.45
			58 15 11	Cockle Point	238 13 50	4192.4	4584.7	2.61
South River	34 58 40.38	76 34 56.79	196 16 41	Neuse River light	16 18 02	12690.7	13878.2	7.89
			147 02 46	Cockle Point	327 00 52	9238.4	10102.8	5.74
Brant Island	35 12 27.24	76 26 10.97	10 51 47	Point of Marsh	190 50 39	15985.1	17480.8	9.93
			36 17 34	Neuse River light	216 13 52	16491.7	18034.9	10.25
Brant Island light	35 08 05.00	76 17 17.53	65 17 42	Point of Marsh	245 11 27	18191.9	19894.1	11.30
			120 57 09	Brant Island	300 52 02	15731.1	17203.1	9.77
Man Point	35 09 02.32	76 31 53.48	328 52 43	Point of Marsh	148 54 52	10960.2	11985.7	6.81
			8 50 40	Neuse River light	188 50 15	7067.0	7728.3	4.39
Bay River Point	35 10 57.40	76 31 14.82	11 06 04	Neuse River light	191 05 17	10729.6	11733.6	6.67
			15 25 33	Man Point	195 25 11	3678.6	4022.8	2.29
Great Hammock	35 10 20.88	76 33 36.78	252 35 34	Bay River Point	72 36 56	3763.9	4116.1	2.34
			312 47 36	Man Point	132 48 35	3562.9	3896.3	2.21
Steep Point	35 00 00.58	76 29 24.77	153 26 48	Neuse River light	333 24 58	10856.6	11872.4	6.75
			194 32 52	Point of Marsh	14 33 35	7550.9	8257.5	4.69
Pitman	34 59 16.22	76 29 55.20	107 29 00	Brown's Creek	287 27 19	4681.0	5119.0	2.91
			209 26 51	Steep Point	29 27 08	1569.6	1716.5	0.98
Tall tree	34 59 36.15	76 31 14.17	287 03 09	Pitman	107 03 54	2094.5	2290.5	1.30
			107 49 03	Brown's Creek	287 48 07	2586.0	2828.0	1.61
Piney Island, pine	34 58 59.18	76 27 42.50	98 52 34	Pitman	278 51 18	3405.7	3724.3	2.12
			126 07 11	Steep Point	306 06 12	3209.7	3510.0	1.99
Round top pine	34 57 41.52	76 28 57.82	153 30 03	Pitman	333 29 30	3260.9	3566.0	2.03
			170 56 33	Steep Point	350 56 18	4339.1	4745.2	2.70
Rattan, flag	35 02 30.52	76 27 57.50	58 25 08	Brown's Creek	238 22 19	8743.5	9561.6	5.43
			173 20 45	Point of Marsh	353 20 38	2706.4	2959.6	1.68
Piney Point, flag	35 05 54.83	76 33 49.33	352 17 45	Brown's Creek	172 18 18	10976.3	12003.4	6.82
			206 54 06	Man Point	26 55 13	6478.9	7085.1	4.03
Ball's Island	35 11 34.93	76 33 36.46	287 52 43	Bay River Point	107 54 05	3765.2	4117.5	2.34
			0 12 19	Great Hammock	180 12 19	2282.0	2495.5	1.42
Sanders Point	35 11 11.15	76 35 36.39	256 24 29	Ball's Island	76 25 38	3120.9	3412.9	1.94
			297 05 59	Great Hammock	117 07 08	3399.3	3717.4	2.11
Davis Island	35 10 04.11	76 34 55.93	153 38 39	Sanders Point	333 38 16	2305.3	2521.0	1.43
			215 41 14	Ball's Island	35 42 00	3445.8	3768.2	2.14
Ireland	35 09 37.37	76 36 52.50	213 40 34	Sanders Point	33 41 18	3472.5	3797.4	2.16
			254 23 00	Davis Island	74 24 07	3062.7	3349.3	1.90
Pettys Point	35 10 21.95	76 37 49.80	277 06 28	Davis Island	97 08 08	4433.6	4848.4	2.76
			313 26 53	Ireland	133 27 26	1997.3	2184.2	1.24
Bells Point	35 09 58.45	76 38 55.81	246 33 10	Pettys Point	66 33 48	1820.2	1990.5	1.13
			281 44 59	Ireland	101 46 10	3186.6	3484.8	1.98
Windmill Point	35 10 25.20	76 39 41.00	272 01 55	Pettys Point	92 02 59	2815.3	3078.7	1.75
			305 46 55	Bells Point	125 47 21	1409.8	1541.7	0.88

GEOGRAPHICAL POSITIONS—Continued.

Section IV.—Neuse River, N. C.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Lamberts Point	35 09 26.03	76 40 30.58	247 01 58	Pettys Point	67 03 30	4418.2	4831.6	2.75
			247 22 53	Bells Point	67 23 47	2597.9	2840.9	1.61
Jones Bay, flag	35 13 26.87	76 30 27.18	14 39 52	Bay River Point	194 39 25	4760.9	5206.4	2.96
			285 48 47	Brant Island	105 51 15	6734.6	7364.7	4.18

Section V.—Vicinity of Charleston, S. C.

CHARLESTON, ST. MICHAEL'S CHURCH.	32 46 34.48	79 55 37.90	....	....	....	....	....	....
BEACON HOUSE, OR WESTOVER-ALL BEACON, 1849.	32 43 01.80	79 52 02.57	139 27 58	St. Michael's Church	319 26 01	8621.8	9428.6	5.36
Crusoe	32 40 11.44	79 54 09.11	168 55 14	St. Michael's Church	348 54 26	12023.0	13148.0	7.47
			212 07 19	Beacon House	32 08 27	6196.7	6776.5	3.85
Morris Island, signal station	32 41 30.39	79 52 23.83	48 26 31	Crusoe	228 25 34	3665.6	4008.6	2.28
			191 07 17	Beacon House	11 07 28	2869.8	3138.3	1.78
Charleston light, hydrographic signal.	32 41 55.93	79 52 28.98	198 42 58	Beacon House	18 43 12	2142.5	2342.9	1.33
			150 11 36	St. Michael's Church	330 09 54	9889.5	10814.9	6.15
Black Island	32 42 20.55	79 54 04.28	1 49 00	Crusoe	181 48 57	3978.9	4351.2	2.47
			248 08 30	Beacon House	68 09 35	3414.9	3734.5	2.12
Bailey	32 40 51.62	79 53 58.23	244 05 06	Signal station	64 05 57	2733.6	2989.3	1.70
			12 54 24	Crusoe	192 54 18	1269.8	1388.6	0.79
Donkey	32 40 45.28	79 55 05.40	263 38 21	Bailey	83 38 57	1760.7	1925.5	1.09
			305 24 43	Crusoe	125 25 13	1799.4	1967.8	1.12
Barrel	32 39 48.45	79 55 48.08	212 25 06	Donkey	32 25 29	2073.8	2267.9	1.29
			254 38 34	Crusoe	74 39 27	2673.9	2924.1	1.66
Broad Island	32 40 17.16	79 56 39.95	272 33 24	Crusoe	92 34 46	3933.7	4301.7	2.44
			303 11 17	Barrel	123 11 45	1615.0	1766.1	1.00
Contraband	32 39 26.38	79 56 54.88	193 58 01	Broad Island	13 58 09	1611.7	1762.5	1.00
			248 39 27	Barrel	68 40 03	1868.7	2043.5	1.16
Battery Purveyance, flag-staff	32 41 35.71	79 53 04.42	278 48 15	Signal station	98 48 37	1069.8	1169.9	0.66
			131 32 32	Black Island	311 32 00	2082.8	2277.7	1.29
Signal station No. 2	32 41 34.51	79 52 28.83	45 36 04	Crusoe	225 35 10	3656.5	3998.6	2.27
			60 25 40	Bailey	240 24 52	3677.2	4021.3	2.28
Fort Wagner, flag-staff	32 43 49.96	79 51 53.21	51 06 24	Black Island	231 05 13	4385.4	4795.7	2.73
			14 51 17	Charleston light, hydr	194 50 58	3633.6	3973.6	2.26
Turniptop pine	32 41 00.78	79 53 11.07	150 35 05	Black Island	330 34 36	2821.2	3085.2	1.75
			77 03 30	Bailey	257 03 05	1260.3	1378.2	0.78
Secessionville, flag-staff	32 42 13.86	79 56 30.91	258 02 53	Beacon House	78 05 18	7141.8	7810.1	4.44
			315 35 06	Crusoe	135 36 23	5278.3	5772.2	3.28
Palmetto	32 41 11.96	79 53 35.94	253 10 39	Signal station	73 11 18	1962.0	2145.6	1.22
			160 44 46	Black Island	340 44 31	2238.0	2447.4	1.39
Dietz	32 41 56.32	79 53 39.21	13 33 27	Crusoe	193 33 11	3323.4	3634.3	2.06
			231 16 46	Beacon House	51 17 38	3225.3	3527.1	2.00
Lone two-story house, north chimney.	32 43 05.49	79 56 20.95	291 14 35	Black Island	111 15 49	3818.7	4176.0	2.37
			327 21 04	Crusoe	147 22 15	6367.0	6962.8	3.96
James Island, long yellow house, chimney in center.	32 43 47.41	79 55 02.16	286 42 51	Beacon House	106 44 28	4882.9	5339.8	3.03
			348 16 06	Crusoe	168 16 35	6794.8	7430.5	4.22
Swamp Angel	32 43 13.07	79 53 10.19	339 06 18	Signal station	159 06 43	3385.7	3702.5	2.10
			335 41 02	Charleston light, hydr	155 41 24	2606.4	2850.3	1.62
Ft. Johnson observatory, (rebel)	32 45 01.17	79 53 55.26	2 18 53	Crusoe	182 18 46	8931.6	9767.3	5.55
			340 31 28	Signal station No. 2	160 32 15	6751.5	7383.2	4.19
Sentry box	32 41 17.58	79 52 55.69	137 21 02	Black Island	317 20 25	2636.8	2883.5	1.64
			210 29 34	Charleston light, hydr	30 29 48	1371.4	1499.7	0.85
Telegraph pole	32 41 32.83	79 53 20.30	272 54 23	Signal station	92 54 53	1473.0	1610.8	0.92
			142 04 29	Black Island	322 04 05	1863.5	2037.8	1.16
Breach Inlet Observatory (rebel).	32 46 22.55	79 48 48.08	31 59 10	Signal station	211 57 13	10607.7	11600.2	6.59
			47 51 34	Black Island	227 48 43	11105.1	12144.2	6.90
Carpenter shop, flag-staff	32 41 21.16	79 52 34.56	128 03 44	Black Island	308 02 55	2967.3	3245.0	1.84
			224 28 58	Signal station	44 29 04	398.8	436.1	0.25

GEOGRAPHICAL POSITIONS—Continued.

Section V.—Vicinity of Charleston, S. C.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Battery Marshall, flag-staff	32 46 20.94	79 48 43.02	32 44 04	Signal station	212 42 05	10638.0	11633.3	6.61
			46 48 07	Fort Wagner, flag-staff	226 46 24	6790.9	7426.3	4.22
Housatonic wreck, main-mast (April 25, 1864).	32 43 08.06	79 46 27.08	98 40 12	Fort Wagner, flag-staff	278 37 16	8588.8	9392.4	5.34
			65 42 20	Crusoe	245 38 10	13206.6	14442.3	8.21
Skylight in roof on Pawnee Landing.	32 40 04.37	79 54 54.35	167 07 44	Donkey	347 07 38	1292.9	1413.9	0.80
			225 07 42	Bailey	45 08 12	2062.9	2255.9	1.28
North gable, Pawnee Landing	32 40 02.58	79 55 04.45	228 47 27	Bailey	48 48 03	2293.2	2507.8	1.43
			69 03 30	Barrel	249 03 06	1217.7	1331.0	0.76
Lookont tower (rebel), at Secessionville.	32 42 34.19	79 56 28.12	320 31 12	Crusoe	140 32 27	5695.8	6228.7	3.54
			276 23 41	Black Island	96 24 59	3769.6	4122.3	2.34
Black Island Battery, flag-staff	32 42 28.00	79 53 54.65	306 52 21	Signal station	126 53 10	2956.9	3233.5	1.84
			47 31 51	Black Island	227 31 46	340.2	372.0	0.21
Battery Chatfield, flag-staff (old)	32 44 24.27	79 51 58.89	25 23 24	Bailey	205 22 19	7249.5	7927.8	4.50
			2 09 41	Beacon House	182 09 38	2542.8	2780.8	1.58
Battery Chatfield, flag-staff (April 25, 1864).	32 44 23.80	79 51 58.67	40 45 15	Black Island	220 44 07	5010.9	5479.8	3.11
			2 18 03	Beacon House	182 18 01	2527.7	2764.2	1.57
Center of largest house in Secessionville.	32 42 23.69	79 56 02.25	324 06 41	Crusoe	144 07 42	5027.5	5497.9	3.12
			259 19 53	Beacon House	79 22 03	6350.7	6945.0	3.95
Sullivan's Island, South Channel beacon.	32 45 30.82	79 51 10.97	37 37 01	Black Island	217 35 27	7398.1	8090.4	4.60
			16 20 09	Beacon House	196 19 41	4782.7	5230.8	2.97
Dead tree at south end of Black Island.	32 42 19.18	79 54 10.08	298 30 16	Signal station	118 31 13	3148.8	3443.4	1.96
			285 12 34	Charleston light, hydr	105 13 29	2728.6	2983.9	1.70
Saw-mill, smoke-pipe	32 39 46.25	79 55 52.61	127 40 10	Broad Island	307 39 44	1558.4	1704.2	0.97
			240 03 43	Barrel	60 03 45	136.3	149.1	0.08
Saw-mill, north gable	32 39 46.14	79 55 52.41	127 38 52	Broad Island	307 38 27	1564.0	1710.4	0.97
			237 40 03	Barrel	57 40 05	133.5	146.0	0.08
Mud signal	32 40 16.29	79 56 29.23	95 23 35	Broad Island	275 23 29	310.0	339.0	0.19
			308 39 21	Barrel	128 39 43	1372.4	1500.8	0.85
Campbell 2	32 39 17.53	79 57 03.26	228 37 37	Donkey	48 38 41	4091.7	4474.6	2.54
			218 44 03	Contraband	38 44 07	348.3	380.9	0.22
Picket	32 40 20.00	79 56 30.67	20 52 59	Contraband	200 52 46	1767.6	1933.0	1.10
			311 11 55	Barrel	131 12 18	1475.4	1613.4	0.92
Old chimney in ruins	32 40 51.38	79 57 49.02	301 35 22	Barrel	121 36 27	3699.2	4045.4	2.30
			300 21 18	Broad Island	120 21 55	2086.0	2281.2	1.30
Folly Island, flag-staff No. 3	32 38 55.82	79 56 40.34	150 06 54	Contraband	338 06 46	1014.4	1109.3	0.63
			239 24 12	Crusoe	59 25 34	4577.2	5005.5	2.84
Folly Island, flag-staff No. 4	32 38 40.48	79 57 06.54	192 09 35	Contraband	12 09 41	1446.1	1581.4	0.90
			193 05 55	Broad Island	13 06 09	3057.6	3343.7	1.90
Folly Island, flag-staff No. 5	32 38 08.54	79 57 57.56	207 02 07	Broad Island	27 02 49	4448.1	4864.3	2.76
			237 31 47	Crusoe	57 33 50	7054.6	7714.7	4.38
Folly Island, flag-staff No. 6	32 37 57.44	79 58 12.06	209 08 35	Broad Island	29 09 25	4927.7	5388.8	3.06
			236 52 50	Crusoe	56 55 01	7557.4	8264.6	4.70
Tall pine in small hammock	32 40 11.58	79 56 42.38	13 08 36	Contraband	193 08 29	1429.6	1563.4	0.89
			200 24 15	Broad Island	20 24 16	183.1	200.2	0.11
Ragged	32 39 48.51	79 56 29.48	162 49 21	Broad Island	342 49 15	923.7	1010.1	0.57
			270 04 58	Barrel	90 05 20	1078.8	1179.7	0.67
Beach	32 40 49.27	79 53 21.83	206 48 53	Beacon House	26 49 36	4574.5	5002.5	2.84
			46 34 32	Crusoe	226 34 07	1695.5	1854.1	1.05
Signal station No. 3	32 41 40.91	79.52 25.47	44 25 17	Crusoe	224 24 21	3857.9	4218.8	2.40
			104 31 40	Secessionville, tower	284 32 29	6529.1	7140.1	4.06
Fort Sumter 3	32 45 08.40	79 52 13.47	2 47 59	Signal station No. 3	182 47 52	6398.8	6997.5	3.98
			54 24 00	Secessionville, tower	234 21 42	8155.8	8918.9	5.07
Fort Johnson 3	32 45 05.19	79 53 39.37	267 27 40	Fort Sumter 3	87 28 27	2238.1	2447.6	1.39
			342 59 26	Signal station No. 3	163 00 06	6580.0	7195.7	4.09
Moultrie beacon	32 45 34.13	79 50 58.10	68 00 08	Fort Sumter 3	247 59 27	2115.7	2313.6	1.31
			78 01 10	Fort Johnson 3	257 59 43	4291.0	4692.5	2.67
Fort Marshall	32 46 20.73	79 48 43.19	33 53 38	Signal station No. 3	213 51 38	10381.7	11353.2	6.45
			67 51 57	Fort Sumter 3	247 50 03	5908.6	6461.5	3.67
Castle Pinckney 2	32 46 25.12	79 54 25.43	286 12 42	Moultrie beacon	106 14 34	5619.4	6145.2	3.49
			334 02 01	Fort Johnson 3	154 02 26	2738.3	2994.5	1.70

GEOGRAPHICAL POSITIONS—Continued.

Section V.—Vicinity of Charleston, S. C.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Shem	32 47 10.77	79 53 24.66	5 39 02	Fort Johnson 3	185 38 54	3887.3	4251.1	2.42
			48 21 15	Castle Pinckney 2	228 20 42	2116.1	2314.1	1.32
Hobcaw 2	32 48 45.39	79 54 10.85	335 26 15	Fort Sumter 3	155 27 19	7350.3	8038.0	4.57
			337 35 08	Shem	157 35 33	3150.7	3445.5	1.96
James	32 45 33.66	79 56 19.76	241 57 05	Castle Pinckney 2	61 58 07	3371.3	3686.7	2.09
			236 41 52	Shem	56 43 27	5450.2	5960.2	3.39
King	32 47 58.05	79 43 48.34	68 21 27	Fort Sumter 3	248 16 54	14144.7	15468.2	8.79
			68 40 40	Fort Marshall	248 38 00	8236.8	9007.5	5.12
Battery Bee, flag-staff	32 45 51.53	79 51 38.03	65 41 23	Fort Johnson 3	245 40 17	3466.0	3790.3	2.15
			34 46 02	Fort Sumter 3	214 45 43	1617.2	1768.5	1.00
Battery Beauregard, flag-staff	32 45 29.51	79 50 42.13	80 47 34	Fort Johnson 3	260 45 46	4673.7	5111.0	2.90
			106 26 34	Castle Pinckney 2	286 24 18	6058.6	6625.5	3.76
Castle Pinckney, flag-staff	32 46 24.66	79 54 26.56	333 21 39	Fort Johnson 3	153 22 05	2738.8	2995.0	1.70
			304 07 45	Fort Sumter 3	124 08 57	4185.2	4576.8	2.60
Etiwan	32 45 20.98	79 53 07.00	285 32 02	Fort Sumter 3	105 32 31	1446.1	1581.4	0.90
			60 00 51	Fort Johnson 3	240 00 34	972.9	1064.0	0.60
Glover	32 45 08.84	79 55 31.05	263 43 07	Moultrie beacon	83 45 35	7146.9	7815.6	4.44
			270 08 33	Fort Sumter 3	90 10 20	5142.4	5623.5	3.20
Chimney	32 46 30.43	79 45 26.94	50 43 52	Signal station No. 3	230 40 06	14079.4	15396.8	8.75
			86 39 34	Fort Marshall	266 37 48	5116.1	5594.8	3.18
West chimney	32 46 42.40	79 47 48.57	37 50 24	Signal station No. 3	217 47 54	11756.0	12856.0	7.30
			64 50 48	Fort Marshall	244 50 18	1570.0	1716.9	0.98
Fort Moultrie, flag-staff, (March, 1865.)	32 45 32.84	79 51 12.72	131 18 45	Shem	311 17 34	4570.6	4998.3	2.84
			77 25 58	Fort Johnson 3	257 24 39	3910.8	4276.8	2.43
Fort Moultrie, flag-staff, (June, 1865.)	32 45 33.51	79 51 14.72	14 25 27	Signal station No. 3	194 24 49	7397.8	8090.0	4.60
			63 10 21	Fort Sumter 3	243 09 49	1713.5	1873.8	1.06
Mount Pleasant light	32 47 02.12	79 52 15.01	359 20 47	Fort Sumter 3	179 20 48	3503.0	3830.8	2.18
			31 22 07	Fort Johnson 3	211 21 17	4217.9	4612.5	2.62
Charleston, cathedral	32 46 50.26	79 56 13.87	261 49 03	Shem	81 50 35	4447.6	4863.7	2.76
			308 49 18	Fort Johnson 3	128 50 42	5161.4	5644.3	3.21
Presbyterian church spire	32 47 14.16	79 55 51.31	319 08 10	Fort Johnson 3	139 09 21	5251.5	5742.8	3.26
			222 55 02	Hobcaw 2	42 55 56	3834.9	4193.8	2.38
Saint Philipp's church spire	32 46 44.26	79 55 32.58	256 12 01	Shem	76 13 10	3426.8	3747.4	2.13
			209 40 32	Hobcaw 2	29 41 16	4294.6	4696.4	2.67
White Point Garden, flag-staff	32 46 11.78	79 55 39.20	257 55 05	Castle Pinckney 2	77 55 45	1963.0	2146.7	1.22
			242 33 37	Shem	62 34 50	3944.4	4313.5	2.45
Wharf	32 47 42.94	79 54 18.34	4 23 39	Castle Pinckney 2	184 23 35	2404.8	2629.8	1.49
			305 20 08	Shem	125 20 37	1711.5	1871.6	1.06
Fort Johnson, flag-staff	32 44 58.40	79 53 47.47	159 42 19	Castle Pinckney 2	339 41 58	2848.0	3114.4	1.77
			225 14 13	Fort Johnson 3	45 14 17	297.0	324.8	0.18
Fort Putnam, flag-staff	32 44 26.38	79 52 07.70	116 36 41	Fort Johnson 3	296 35 51	2668.9	2918.6	1.66
			135 35 04	Castle Pinckney 2	315 33 50	5121.5	5600.7	3.18
Fort Ripley, flag-staff	32 45 53.65	79 54 05.64	295 30 54	Fort Sumter 3	115 31 55	3235.2	3537.9	2.01
			277 00 31	Moultrie beacon	97 02 12	4917.5	5377.6	3.06
Fort Sumter, flag-staff	32 45 08.42	79 52 15.31	2 22 07	Signal station No. 3	182 22 02	6397.5	6996.1	3.97
			87 23 48	Fort Johnson 3	267 23 03	2190.3	2395.2	1.36
Bradford 1	32 42 12.01	79 52 14.62	180 18 58	Fort Sumter 3	0 18 58	5433.1	5941.5	3.38
			215 40 49	Fort Marshall	35 42 43	9433.0	10315.7	5.86
Bradford 2	32 42 38.27	79 ,2 07.64	178 07 16	Fort Sumter 3	358 07 13	4626.6	5059.5	2.87
			217 49 22	Fort Marshall	37 51 13	8676.0	9487.8	5.39
Bradford 3	32 43 03.85	79 52 01.85	175 29 35	Fort Sumter 3	355 29 29	3848.4	4208.5	2.39
			199 43 04	Moultrie beacon	19 43 38	4917.7	5377.8	3.06
Bradford 4	32 43 20.70	79 51 57.26	172 45 08	Fort Sumter 3	352 44 59	3344.1	3657.0	2.08
			200 32 08	Moultrie beacon	20 32 40	4389.0	4799.6	2.73
Flag-staff 1	32 39 49.12	79 54 48.57	236 13 33	Crusoe	56 13 54	1236.7	1352.4	0.77
			214 15 58	Bailey	34 16 25	2329.4	2547.4	1.45
Flag-staff 2	32 39 09.13	79 56 17.28	240 05 55	Crusoe	60 07 06	3852.3	4212.7	2.39
			228 55 29	Bailey	48 56 44	4804.4	5253.9	2.99

GEOGRAPHICAL POSITIONS—Continued.

Section V.—Broad River and Whale Branch.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Daw	32 18 12.17	80 44 14.91						
Banana	32 19 57.05	80 46 31.09	312 11 55	Daw	132 13 08	4808.4	5258.3	2.99
Archer	32 21 18.92	80 44 24.59	357 28 48	Daw	177 28 53	5757.5	6296.2	3.58
			52 41 24	Banana	232 40 16	4159.0	4548.1	2.58
Lemon	32 22 24.54	80 47 17.22	294 06 57	Archer	114 08 29	4944.8	5407.4	3.07
			345 07 38	Banana	165 08 03	4700.2	5140.0	2.92
Broad	32 23 46.51	80 46 32.02	323 45 39	Archer	143 46 47	5635.5	6162.8	3.50
			359 48 10	Banana	179 48 10	7067.4	7728.7	4.39
New Harbor	32 24 43.69	80 48 58.32	294 43 33	Broad	114 44 51	4209.1	4603.0	2.62
			328 20 25	Lemon	148 21 19	5034.7	5505.8	3.13
New Barnwell	32 26 02.83	80 47 39.10	337 20 22	Broad	157 20 58	4549.8	4975.5	2.83
			355 08 20	Lemon	175 08 32	6747.5	7378.9	4.19
Barnwell	32 26 00.27	80 47 37.64	337 24 12	Broad	157 24 47	4462.5	4880.0	2.77
			355 24 32	Lemon	175 24 43	6666.0	7289.8	4.14
Harbor	32 24 53.97	80 48 36.50	302 33 43	Broad	122 34 50	3859.5	4220.6	2.40
			335 45 36	Lemon	155 46 18	5047.1	5519.4	3.14
Boyd's Neck	32 27 25.31	80 49 22.39	313 16 33	New Barnwell	133 17 29	3705.7	4052.4	2.30
			352 48 06	New Harbor	172 48 19	5017.7	5487.2	3.12
Live Oak	32 28 28.69	80 48 24.39	345 14 52	New Barnwell	165 15 16	4645.7	5080.4	2.89
			7 17 27	New Harbor	187 17 09	6986.6	7640.3	4.34
Gopher	32 28 40.82	80 49 18.62	284 47 00	Live Oak	104 47 29	1464.4	1601.4	0.91
			2 25 23	Boyd's Neck	182 25 21	2327.8	2545.6	1.45
Grant	32 30 00.76	80 48 53.14	345 10 26	Live Oak	165 10 42	2933.6	3208.1	1.82
			15 07 10	Gopher	195 06 56	2550.5	2789.1	1.58
Branch	32 29 39.20	80 48 24.36	0 01 01	Live Oak	180 01 01	2171.8	2375.0	1.35
			38 14 02	Gopher	218 13 33	2288.9	2503.0	1.42
Whale 2	32 28 42.62	80 47 49.20	88 38 51	Gopher	268 38 03	2335.4	2553.9	1.45
			152 13 12	Branch	332 12 53	1969.7	2154.0	1.22
Yorick	32 29 12.04	80 46 48.99	60 02 21	Whale 2	240 01 49	1814.4	1984.2	1.13
			108 34 27	Branch	288 33 36	2626.5	2872.3	1.63
Dove	32 29 49.16	80 47 07.15	337 28 05	Yorick	157 28 15	1237.7	1353.5	0.77
			28 10 25	Whale 2	208 10 03	2324.8	2542.3	1.44
Cole	32 30 05.70	80 46 47.99	0 54 09	Yorick	180 54 09	1652.7	1807.4	1.03
			44 29 11	Dove	224 29 01	713.9	780.7	0.44
Berry	32 30 25.52	80 47 22.72	303 57 29	Cole	123 57 48	1092.9	1195.2	0.68
			340 03 22	Dove	160 03 30	1191.3	1302.7	0.74
Tree	32 30 28.80	80 46 42.44	27 51 03	Dove	207 50 50	1381.0	1510.2	0.86
			11 30 23	Cole	191 30 20	726.3	794.3	0.45
Nest	32 30 26.85	80 46 50.70	353 47 26	Cole	173 47 27	655.4	716.7	0.41
			20 17 52	Dove	200 17 43	1237.7	1353.5	0.77
Eagle	32 29 09.51	80 47 49.57	135 11 25	Branch	315 11 06	1288.9	1409.5	0.80
			267 10 13	Yorick	87 10 46	1583.4	1731.5	0.98
Fish	32 30 37.74	80 50 07.45	300 25 07	Grant	120 25 47	2249.3	2459.8	1.40
			340 30 17	Gopher	160 30 43	3820.2	4177.6	2.37
Hall	32 31 27.67	80 49 53.95	329 19 52	Grant	149 20 25	3111.9	3403.1	1.93
			12 54 16	Fish	192 54 09	1577.6	1725.2	0.98
Flat-top pine, Parry Island	32 19 18.57	80 41 05.11	125 24 52	Archer	305 23 05	6399.0	6997.7	3.98
			120 30 57	Lemon	300 27 38	11290.3	12346.7	7.01
Tall pine, Parry Island	32 20 24.28	80 41 53.62	113 06 01	Archer	293 04 40	4290.7	4692.2	2.67
			113 40 11	Lemon	293 37 18	9235.3	10099.4	5.74
Barrel, east	32 21 46.95	80 45 09.30	306 26 46	Archer	126 27 10	1453.2	1589.2	0.90
			347 51 44	Daw	167 52 13	6766.5	7399.6	4.20
Large dead tree	32 22 06.73	80 48 39.12	255 36 23	Lemon	75 37 07	2209.9	2416.7	1.37
			227 13 12	Broad	47 14 20	4525.2	4948.6	2.81
Stake in water	32 23 42.08	80 48 14.38	148 49 26	New Harbor	328 49 02	2218.0	2425.5	1.38
			267 04 26	Broad	87 05 21	2678.2	2928.8	1.66
White and red flag	32 23 19.46	80 47 53.43	330 46 30	Lemon	150 46 49	1938.1	2119.5	1.20
			248 36 27	Broad	68 37 11	2284.9	2498.7	1.42

GEOGRAPHICAL POSITIONS—Continued.

Section V.—Broad River and Whale Branch.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Dead tree near hammock	32 22 26.70	80 50 03.59	246 01 03	Broad	66 02 56	6051.1	6617.3	3.76
			202 00 20	New Harbor	22 00 55	4551.0	4976.8	2.83
Tall dead tree	32 24 53.55	80 49 50.56	282 32 12	New Harbor	102 32 40	1398.0	1528.8	0.87
			238 08 04	New Barnwell	58 09 14	4043.1	4421.4	2.51
White Hall, center	32 26 39.98	80 51 50.33	302 41 36	Broad	122 44 27	9881.6	10806.2	6.14
			302 48 39	Harbor	122 50 23	6027.4	6591.4	3.75
Hazard Hall, center	32 25 09.17	80 50 56.51	290 11 05	Broad	110 13 27	7360.4	8049.1	4.57
			277 18 18	Harbor	97 19 33	3691.0	4036.4	2.29
Double-top pine	32 26 20.26	80 49 56.27	203 47 28	Boyd's Neck	23 47 46	2190.0	2394.9	1.36
			278 30 55	New Barnwell	98 32 09	3624.1	3963.2	2.25
Center of house on Port Royal Island.	32 23 09.60	80 45 06.08	67 58 11	Lemon	247 57 01	3698.7	4044.8	2.30
			342 20 10	Archer	162 20 32	3577.3	3912.0	2.22
Tallest of two trees, long lower limb.	32 26 24.28	80 47 04.59	117 35 30	Boyd's Neck	297 34 16	4060.2	4440.1	2.52
			2 33 42	Lemon	182 33 35	7391.7	8083.4	4.59
White-washed palmetto	32 26 42.32	80 49 15.28	202 04 24	Live Oak	22 04 51	3535.4	3866.2	2.20
			295 49 58	New Barnwell	115 50 49	2791.1	3052.3	1.73
Red cross	32 27 47.55	80 49 11.01	199 29 51	Branch	19 30 16	3648.2	3989.6	2.27
			23 27 03	Boyd's Neck	203 26 57	746.6	816.4	0.46
Whale 1	32 28 07.34	80 48 26.59	2 29 22	Harbor	182 29 17	5961.7	6519.6	3.70
			341 54 28	Barnwell	161 54 54	4117.3	4502.6	2.56
Island	32 28 07.13	80 48 26.08	127 05 33	Gopher	307 06 01	1720.0	1880.9	1.07
			48 47 14	Boyd's Neck	228 46 44	1954.5	2137.4	1.21
Hog	32 27 38.71	80 49 23.54	355 50 14	Boyd's Neck	175 50 15	413.7	452.4	0.26
			183 50 15	Gopher	3 50 18	1917.3	2096.7	1.19
Lath	32 28 58.16	80 48 20.65	175 36 55	Branch	355 36 53	1267.6	1386.2	0.79
			156 15 43	Grant	336 15 26	2106.4	2303.5	1.31
Blue flag	32 29 05.79	80 49 04.43	225 27 35	Branch	45 27 57	1467.2	1604.5	0.91
			25 43 38	Gopher	205 43 30	853.6	933.4	0.53
White and black pole	32 29 37.42	80 49 36.62	156 35 10	Fish	336 34 53	2024.9	2214.4	1.26
			237 38 22	Grant	57 38 45	1343.6	1469.3	0.84
Tall straight dead tree	32 30 16.07	80 48 50.80	13 53 55	Gopher	193 54 10	3022.3	3305.1	1.88
			108 27 21	Fish	288 26 40	2109.1	2306.5	1.31
Point	32 31 12.29	80 50 20.55	313 59 48	Grant	134 00 35	3171.5	3468.2	1.97
			342 11 41	Fish	162 11 48	1117.7	1222.3	0.69
West chimney	32 31 48.99	80 50 13.70	321 52 53	Hall	141 53 05	834.6	912.7	0.52
			355 45 10	Fish	175 45 13	2200.4	2406.3	1.37
Picket	32 32 05.42	80 50 53.55	306 46 50	Hall	126 47 22	1941.7	2123.4	1.21
			335 59 10	Fish	155 59 35	2956.2	3232.8	1.84
Crow Tree	32 32 03.93	80 52 11.27	287 18 03	Hall	107 19 17	3753.0	4104.2	2.33
			309 23 46	Fish	129 24 53	4181.6	4572.8	2.60
Bird Tree	32 31 30.11	80 51 37.67	271 35 01	Hall	91 35 57	2707.5	2960.8	1.68
			304 24 30	Fish	124 25 18	2853.8	3120.9	1.77
Bob Tree	32 27 58.61	80 50 50.96	230 59 57	Branch	51 01 16	4924.0	5384.8	3.06
			256 22 56	Live Oak	76 24 15	3937.5	4305.9	2.45
Savannah River, Ga.								
SAVANNAH EXCHANGE, SPIRE	32 04 51.70	81 05 15.05						
SOUTH BASE	32 05 34.15	81 03 05.09	69 01 07	Exchange, spire	248 59 58	3649.6	3991.1	2.27
Fort Jackson 2	32 04 55.95	81 01 56.94	88 34 17	Exchange, spire	268 32 32	5196.3	5682.5	3.23
			123 21 58	South base	303 21 22	2139.4	2339.6	1.33
Signal station	32 05 15.04	81 00 54.03	70 23 33	Fort Jackson 2	250 23 00	1751.1	1914.9	1.09
			99 43 56	South base	279 42 46	3486.3	3812.5	2.17
Screven's chimney	32 05 36.78	81 02 48.72	312 48 05	Fort Jackson 2	132 48 32	1850.9	2024.1	1.15
			79 22 16	South base	259 22 07	437.0	477.9	0.27
Tatnall	32 05 09.24	81 02 05.33	83 49 00	Exchange, spire	263 47 20	5003.8	5472.0	3.11
			264 32 08	Signal station	84 32 46	1877.8	2053.5	1.17
Bruton's rice-mill, chimney	32 04 24.40	81 03 19.28	245 45 33	Fort Jackson 2	65 46 17	2367.8	2589.3	1.47
			234 32 12	Tatnall	54 32 51	2380.8	2603.6	1.48
Derrick	32 05 22.63	81 02 02.39	277 26 30	Signal station	97 27 06	1807.5	1976.6	1.12
			102 10 20	South base	282 09 47	1681.5	1838.8	1.05

GEOGRAPHICAL POSITIONS—Continued.

Section V.—Savannah River, Ga.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Smith's rice-mill, chimney	32 06 15.09	81 01 06.89	37 04 34	Tatnall	217 04 03	2541.7	2779.6	1.58
			28 18 22	Fort Jackson 2	208 17 55	2768.2	3027.2	1.72
Fig Island light	32 04 56.59	81 03 33.34	212 37 31	South base	32 37 46	1373.8	1502.4	0.85
			270 26 52	Fort Jackson 2	90 27 43	2528.0	2764.5	1.57
White house	32 05 49.39	81 01 53.20	3 24 37	Fort Jackson 2	183 24 35	1648.5	1802.8	1.02
			304 17 17	Signal station	124 17 48	1877.8	2053.5	1.17
Fort Jackson, flag-staff	32 04 54.04	81 01 57.59	156 33 12	Tatnall	336 33 08	510.3	558.0	0.32
			196 04 35	Fort Jackson 2	16 04 35	61.3	67.0	0.04
Torpedo	32 05 01.11	81 02 28.69	247 45 39	Tatnall	67 45 51	661.8	723.8	0.41
			280 47 34	Fort Jackson 2	100 47 51	847.5	926.8	0.53
Steam saw-mill, chimney	32 05 20.26	81 05 53.37	276 49 39	Fort Jackson 1	96 51 44	6214.8	6796.3	3.86
			311 12 14	Exchange, spire	131 12 34	1335.3	1460.2	0.83
Cheves, tall chimney	32 06 07.10	81 04 26.69	253 37 34	North base	73 38 03	3052.6	3338.2	1.90
			247 55 06	Daniell	67 55 48	2248.6	2459.0	1.40
Judge Huger's, tall chimney	32 06 34.04	81 05 05.32	300 19 43	South base	120 20 47	3651.5	3993.1	2.27
			121 07 42	King	301 06 35	4005.3	4380.1	2.49
Manigault's red brick-mill, chimney.	32 10 59.74	81 07 00.32	75 56 58	Drakie	255 55 49	3475.6	3800.8	2.16
			37 23 15	Potter	217 22 19	4515.4	4937.9	2.81
Manigault's pounding-mill, east ball.	32 10 25.22	81 07 12.52	94 06 26	Drakie	274 05 24	3059.8	3346.1	1.90
			43 48 42	Potter	223 47 53	3498.5	3825.9	2.17
Black iron chimney at Coleraine	32 09 54.70	81 09 11.78	183 33 28	Drakie	3 33 29	1160.8	1269.4	0.72
			336 05 20	Potter	156 05 34	1733.9	1896.2	1.08
Fort Pulaski, flag-staff	32 01 37.07	80 53 13.52	194 42 02	Mungen	14 42 34	6169.8	6747.1	3.83
			277 08 57	Tybee light	97 10 23	4288.0	4689.2	2.66
Tybee beacon	32 01 17.20	80 50 05.25	97 04 37	Fort Pulaski, flag-staff	277 02 59	4977.7	5443.4	3.09
			152 52 25	Mungen	332 51 17	7393.7	8085.5	4.59
Turtle	32 03 42.06	80 53 29.97	353 36 23	Fort Pulaski, flag-staff	173 36 32	3873.6	4236.0	2.41
			223 18 09	Mungen	43 18 49	2911.2	3183.6	1.81
Long	32 02 52.35	80 56 03.40	238 45 44	Mungen	58 47 46	7040.8	7699.6	4.37
			297 28 11	Fort Pulaski, flag-staff	117 29 41	5023.4	5493.4	3.12
Viele	32 03 58.69	80 56 44.66	257 14 13	Mungen	77 16 37	7282.0	7963.4	4.52
			308 12 16	Fort Pulaski, flag-staff	128 14 08	7049.6	7709.2	4.38
North wreck	32 02 15.81	80 53 31.33	203 03 29	Mungen	23 04 10	5189.9	5675.5	3.22
			59 25 01	Wilmington	239 23 14	6164.2	6741.0	3.83
Pulaski beacon	32 01 49.42	80 53 20.25	335 04 05	Fort Pulaski, flag-staff	155 04 09	419.2	458.5	0.26
			67 27 32	Wilmington	247 25 39	6060.4	6627.4	3.77
Jones	32 03 09.42	80 55 06.10	300 39 38	Square beacon	120 40 30	2988.9	3268.5	1.86
			313 54 52	Fort Pulaski, flag-staff	133 55 52	4100.4	4484.0	2.55
Oyster beacon	32 02 09.20	80 53 52.70	242 51 34	Square beacon	62 51 47	724.2	792.0	0.45
			313 56 03	Fort Pulaski, flag-staff	133 56 24	1462.1	1598.9	0.91
Old tower	32 03 49.53	80 56 35.98	307 30 39	Fort Pulaski, flag-staff	127 32 26	6697.0	7323.7	4.16
			299 14 22	Square beacon	119 16 02	5648.7	6177.2	3.51
House	32 02 02.22	80 54 15.18	246 11 24	Square beacon	66 11 49	1350.5	1476.8	0.84
			295 34 25	Fort Pulaski, flag-staff	115 34 58	1793.6	1961.4	1.11
Bend	32 02 15.73	80 55 10.01	267 13 25	Square beacon	87 14 19	2676.6	2927.0	1.66
			291 16 34	Fort Pulaski, flag-staff	111 17 36	3279.9	3586.8	2.04
Tower 1	32 02 08.89	80 54 50.97	216 31 00	Turtle	36 31 43	3570.7	3904.8	2.22
			290 57 32	Fort Pulaski, flag-staff	110 58 24	2738.0	2994.1	1.70
Bain	32 02 21.32	80 56 18.06	201 56 18	Long	21 56 26	1030.0	1126.4	0.64
			285 42 25	Fort Pulaski, flag-staff	105 44 03	5029.7	5500.4	3.13
Bird	32 03 36.60	80 57 16.31	300 00 10	Fort Pulaski, flag-staff	120 02 19	7356.8	8045.1	4.57
			291 31 11	Square beacon	111 33 12	6434.9	7037.1	4.00
Brick beacon	32 01 56.11	80 53 05.26	20 23 47	Fort Pulaski, flag-staff	200 23 43	624.6	683.0	0.39
			194 04 45	Mungen	14 05 12	5547.4	6066.5	3.45
Braddock 2	32 06 59.49	80 47 48.42	60 21 29	Mungen	240 19 08	8006.8	8756.0	4.97
			55 50 42	Turtle	235 47 41	10825.4	11838.3	6.73
Gove	32 09 02.90	80 43 39.81	35 11 48	Tybee beacon	215 08 23	17546.6	19188.4	10.90
			57 28 35	Turtle	237 23 21	18357.4	20075.1	11.41
Cholera	32 06 47.71	80 48 52.01	10 41 30	Tybee beacon	190 40 51	10359.8	11329.2	6.44
			55 47 26	Mungen	235 45 39	6398.8	6997.5	3.98

GEOGRAPHICAL POSITIONS.—Continued.

Section V.—Savannah River, Ga.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Black Ball	32 00 53.96	80 52 41.43	147 37 15	Fort Pulaski, flag-staff	327 36 58	1572.5	1719.6	0.98
			185 40 05	Mungen	5 40 20	7331.5	8017.5	4.56
Buck	32 08 14.80	80 45 25.63	29 42 29	Tybee beacon	209 40 01	14805.2	16190.5	9.20
			56 33 02	Turtle	236 28 45	15224.9	16649.5	9.46
Tower 3	32 04 19.65	80 58 06.08	264 02 12	Mungen	84 05 19	9286.3	10155.2	5.77
			303 06 12	Fort Pulaski, flag-staff	123 08 47	9162.6	10019.9	5.69
Tower 4	32 05 39.86	80 59 16.24	308 05 29	Viele	128 06 50	5049.8	5522.3	3.14
			323 18 20	Tower 3	143 18 57	3080.3	3368.5	1.91
Tower 2	32 04 24.99	80 57 22.90	264 22 26	Mungen	84 25 10	8141.8	8903.7	5.06
			81 46 36	Tower 3	261 46 13	1142.1	1249.0	0.71
Round beacon	32 01 21.33	80 52 34.94	270 52 47	Tybee light	90 53 52	3242.9	3546.4	2.01
			152 19 31	Square beacon	322 19 03	2280.4	2493.7	1.42

Section VI.—Charlotte Harbor, Fla.

Sanibel Island base, east end	26 26 54.33	82 01 10.35	....	....	....	....	....	.....
Sanibel Island base, west end	26 26 01.19	82 02 57.67	241 11 00	East base	61 11 48	3393.2	3710.7	2.11
Middle Point	26 28 12.33	82 03 24.47	302 51 38	East base	122 52 38	4423.0	4836.9	2.75
			349 34 39	West base	169 34 51	4103.4	4487.3	2.55
Punta Rasa	26 29 15.32	82 00 37.40	11 52 44	East base	191 52 29	4433.7	4848.5	2.76
			67 16 46	Middle Point	247 15 32	5016.3	5485.7	3.12
Sword Point	26 31 31.93	82 02 17.85	326 30 31	Punta Rasa	146 31 16	5040.7	5512.4	3.13
			16 43 13	Middle Point	196 42 43	6413.4	7013.5	3.98
Bowditch Point	26 27 34.35	81 57 20.20	78 35 41	East base	258 34 03	6221.2	6803.3	3.87
			120 56 44	Punta Rasa	300 55 20	6044.3	6609.9	3.76
Sanibel	26 25 55.03	82 06 38.28	231 47 04	Middle Point	51 48 30	6831.7	7471.0	4.24
			268 12 38	West base	88 14 16	6114.6	6686.7	3.80
Havelock	26 30 08.92	82 05 59.45	309 53 06	Middle Point	129 54 15	5593.7	6117.0	3.48
			7 50 21	Sanibel	187 50 04	7886.5	8624.4	4.90
Blind Pass	26 28 55.00	82 10 56.77	254 32 10	Havelock	74 34 23	8541.5	9340.7	5.31
			307 42 17	Sanibel	127 44 13	9052.0	9899.0	5.62
Captiva	26 33 32.81	82 12 08.97	301 30 12	Havelock	121 32 57	11999.9	13122.7	7.46
			346 50 16	Blind Pass	166 50 48	8779.9	9601.4	5.46
Lucknow	26 35 34.78	82 07 53.10	342 34 39	Havelock	162 35 30	10509.9	11493.3	6.53
			62 05 07	Captiva	242 03 12	8013.3	8763.1	4.98
Captive Pass	26 36 40.01	82 13 18.27	282 33 34	Lucknow	102 36 00	9216.7	10079.1	5.73
			341 35 11	Captiva	161 35 42	6071.5	6639.6	3.77
Point Ybel	26 27 17.82	82 00 36.62	109 51 11	Middle Point	289 49 56	4942.3	5404.7	3.07
			264 21 37	Bowditch Point	84 23 00	5188.8	5674.3	3.22
San Carlos	26 29 00.16	81 59 27.60	36 19 16	East base	216 18 30	4805.3	5254.9	2.99
			31 15 47	Point Ybel	211 15 16	3684.0	4028.7	2.29
Flag-staff	26 29 18.15	82 00 36.27	66 30 35	Middle Point	246 29 20	5079.1	5554.4	3.16
			301 46 49	Bowditch Point	121 48 12	6063.0	6630.3	3.77
Spanish Curlew	26 29 33.47	82 03 20.88	277 01 22	Punta Rasa	97 02 34	4561.4	4988.2	2.83
			2 16 40	Middle Point	182 16 39	2498.8	2732.6	1.55
Eagle's Nest	26 28 05.87	82 06 26.40	191 08 57	Havelock	11 09 09	3859.5	4220.6	2.40
			267 43 41	Middle Point	87 45 02	5042.8	5514.7	3.13
Josephine	26 29 26.04	82 04 50.44	264 43 42	Spanish Curlew	84 44 22	2490.3	2723.3	1.55
			313 36 28	Middle Point	133 37 07	3288.3	3596.0	2.04
New Year	26 28 44.61	82 07 39.09	226 45 18	Havelock	46 46 02	3787.4	4141.8	2.35
			278 00 05	Middle Point	98 01 59	7121.3	7787.6	4.43
Annie	26 30 58.09	82 10 42.07	208 45 49	Lucknow	28 47 05	9714.3	10623.3	6.04
			309 01 15	New Year	129 02 37	6522.3	7132.6	4.05
Cownpore	26 32 43.57	82 11 20.77	227 28 15	Lucknow	47 29 48	7796.4	8525.9	4.84
			298 07 44	Havelock	118 10 08	10088.3	11032.3	6.27
Oyster-shell	26 32 46.57	82 07 23.10	89 12 37	Cownpore	269 10 51	6578.9	7194.4	4.09
			170 53 24	Lucknow	350 53 10	5242.6	5733.1	3.26
Raccoon Point	26 27 43.57	82 05 45.02	205 36 39	Josephine	25 37 03	3496.9	3824.1	2.17
			257 11 01	Middle Point	77 12 04	3992.2	4365.7	2.48

GEOGRAPHICAL POSITIONS—Continued.

Section VI.—Charlotte Harbor, Fla.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Lawrence	26 29 23.57	82 09 10.14	138 49 03	Annie	318 48 22	3865.1	4226.8	2.40
			205 22 13	Oyster Shell	25 23 01	6914.2	7561.2	4.30
Mellie	26 35 08.39	82 12 13.19	263 32 39	Lucknow	83 34 35	7241.4	7918.9	4.50
			341 58 10	Cownpore	161 58 33	4686.7	5125.2	2.91
Boca Captiva	26 36 43.78	82 13 18.19	283 15 52	Lucknow	103 18 17	9240.4	10105.0	5.74
			341 56 44	Captiva	161 57 15	6181.0	6759.4	3.84
Bocillas	26 42 15.66	82 09 57.88	344 21 58	Lucknow	164 22 54	12809.9	14008.5	7.96
			28 29 01	Boca Captiva	208 27 31	11615.5	12702.3	7.22
Boca Grande	26 43 03.49	82 15 37.75	278 53 10	Bocillas	98 55 43	9507.8	10397.4	5.91
			341 43 02	Boca Captiva	161 44 04	12305.9	13457.4	7.65
Oso	26 47 00.32	82 12 42.77	332 30 50	Bocillas	152 32 04	9874.2	10798.1	6.14
			33 34 06	Boca Grande	213 32 47	8745.9	9564.3	5.43
El Cabo	26 47 05.15	82 08 43.88	12 55 47	Bocillas	192 55 14	9140.7	9996.0	5.68
			56 59 09	Boca Grande	236 56 02	13640.1	14916.4	8.48
Torrey	26 46 37.95	82 03 31.61	52 55 26	Bocillas	232 52 32	13381.6	14633.7	8.31
			95 33 48	El Cabo	275 31 28	8665.8	9476.6	5.38
Brown	26 39 40.54	82 08 59.92	346 15 49	Lucknow	166 16 19	7785.3	8513.8	4.84
			52 43 29	Boca Captiva	232 41 33	8977.9	9817.9	5.58
Inglis	26 37 33.12	82 12 57.56	20 35 50	Boca Captiva	200 35 41	1621.9	1773.7	1.01
			209 43 51	Bocillas	29 45 12	10014.1	10951.1	6.22
Mistake	26 37 46.35	82 10 33.55	67 05 25	Boca Captiva	247 04 11	4944.3	5406.9	3.07
			216 22 39	Brown	36 23 21	4364.7	4773.1	2.71
Useppa	26 39 41.87	82 12 35.21	270 22 52	Brown	90 24 29	5952.6	6509.5	3.70
			140 53 35	Boca Grande	320 52 13	7997.5	8745.8	4.97
Las	26 42 06.08	82 10 33.27	101 52 39	Boca Grande	281 50 22	8598.6	9403.2	5.34
			158 26 54	Oso	338 25 56	9736.4	10647.4	6.05
La Costa	26 39 35.49	82 14 44.97	335 34 01	Boca Captiva	155 34 40	5803.7	6346.7	3.61
			167 09 48	Boca Grande	347 09 24	6565.2	7179.5	4.08
Punta Blanco	26 40 38.66	82 13 20.93	241 58 57	Bocillas	62 00 28	6357.2	6952.1	3.95
			139 41 38	Boca Grande	319 40 36	5845.2	6392.1	3.63
Pelayo	26 45 58.69	82 14 45.04	315 48 13	Las	135 50 06	9982.2	10916.2	6.20
			310 50 30	Bocillas	130 52 39	10491.3	11472.9	6.52
Gasparilla	26 48 23.22	82 16 25.93	292 28 21	Oso	112 30 02	6670.3	7294.4	4.14
			352 17 37	Boca Grande	172 17 59	9929.1	10858.2	6.17
Aguado	26 46 24.89	82 11 14.80	49 32 55	Boca Grande	229 30 57	9549.4	10442.9	5.93
			344 30 27	Bocillas	164 31 02	7959.0	8703.7	4.95
Belinda	26 42 25.52	82 04 49.65	87 58 45	Bocillas	267 56 26	8524.7	9322.3	5.30
			143 04 12	El Cabo	323 02 27	10765.1	11772.4	6.69
Darling	26 40 54.76	82 06 34.21	225 58 23	Belinda	45 59 10	4019.3	4395.4	2.50
			205 31 32	Torrey	25 32 54	11704.8	12800.0	7.27
Kennedy	26 44 13.84	82 03 59.50	69 51 30	Bocillas	249 48 49	10550.6	11537.9	6.56
			34 55 12	Darling	214 54 02	7471.0	8170.1	4.64
Dorr	26 40 41.11	82 05 12.85	100 35 04	Darling	280 34 28	2288.2	2502.3	1.42
			191 17 06	Belinda	11 17 16	3276.6	3583.2	2.04
Matlacha	26 39 20.18	82 06 07.19	164 09 33	Darling	344 09 21	2737.5	2993.6	1.70
			214 09 43	Dorr	34 10 07	2675.0	2925.3	1.66
Rubber	26 38 47.14	82 05 36.22	157 47 22	Darling	337 46 56	4242.0	4638.9	2.64
			146 30 01	Matlacha	326 29 47	1551.7	1696.9	0.96
Gull	26 39 14.43	82 04 41.66	60 54 00	Rubber	240 53 36	1726.5	1888.0	1.07
			100 52 34	Matlacha	280 51 56	2408.1	2633.5	1.50
Owl	26 37 26.23	82 04 56.12	155 59 42	Rubber	335 59 24	2725.9	2981.0	1.69
			186 50 37	Gull	6 50 43	3353.7	3667.5	2.08
Caloosa	26 29 35.71	82 03 08.78	201 31 12	Sword Point	21 31 35	3844.7	4204.4	2.39
			278 30 15	Punta Rasa	98 31 23	4238.9	4635.5	2.63
White	26 32 12.50	82 03 59.27	293 57 47	Sword Point	113 58 32	3073.0	3360.6	1.91
			343 50 21	Caloosa	163 50 44	5023.4	5493.4	3.12
Buttonwood	26 32 56.75	82 03 18.56	327 12 51	Sword Point	147 13 18	3104.5	3395.0	1.93
			39 36 49	White	219 36 31	1767.5	1932.9	1.10
Bailey	26 33 42.05	82 04 34.88	303 25 25	Buttonwood	123 25 59	2530.8	2767.6	1.57
			340 19 17	White	160 19 33	2926.8	3200.6	1.82

GEOGRAPHICAL POSITIONS—Continued.

Section VI.—Charlotte Harbor, Fla.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Grape	26 34 00.55	82 03 39.67	343 25 50	Buttonwood	163 25 59	2048.5	2240.2	1.27
			69 34 22	Bailey	249 33 57	1630.5	1783.0	1.01
Narrows	26 34 56.88	82 03 57.07	344 28 15	Grape	164 28 23	1799.2	1967.6	1.12
			24 26 06	Bailey	204 25 49	2529.2	2765.9	1.57
Deer	26 35 45.59	82 02 36.29	28 28 44	Grape	208 28 16	3677.6	4021.7	2.28
			56 09 09	Narrows	236 08 33	2691.1	2942.9	1.67
Lumber	26 35 57.94	82 03 41.69	359 06 17	Grape	179 06 18	3613.1	3951.2	2.25
			12 45 03	Narrows	192 44 56	1926.6	2106.9	1.20
Meridian	26 37 00.77	82 02 57.82	103 28 20	Owl	283 27 27	3364.5	3679.3	2.09
			145 05 00	Gull	325 04 13	5016.6	5486.0	3.12
Buzzard	26 38 42.40	82 03 52.59	334 09 20	Meridian	154 09 44	3474.9	3800.1	2.16
			36 51 31	Owl	216 51 02	2922.7	3196.2	1.82
Flag in tree	26 37 16.71	82 04 43.34	279 31 49	Meridian	99 32 36	2959.6	3236.5	1.84
			324 52 16	Lumber	144 52 44	2963.8	3241.2	1.84
Pawpaw	26 30 54.67	82 03 10.41	176 33 30	Buttonwood	356 33 26	3763.5	4115.6	2.34
			231 45 27	Sword Point	51 45 50	1852.8	2026.2	1.15
Boots	26 34 59.98	82 04 44.02	315 45 37	Grape	135 46 06	2552.9	2791.8	1.59
			353 58 26	Bailey	173 58 30	2411.6	2637.2	1.50
Punta Gorda	26 53 36.07	82 05 22.05	346 39 43	Torrey	166 40 33	13224.0	14461.4	8.22
			24 51 53	El Cabo	204 50 22	13258.2	14498.8	8.24
Flat	26 49 40.93	82 14 02.78	335 54 27	Oso	155 55 03	5414.2	5920.8	3.36
			58 49 55	Gasparilla	238 48 50	4619.7	5052.0	2.87
Mound	26 48 22.96	82 10 36.94	53 48 27	Oso	233 47 30	4306.2	4709.1	2.68
			112 54 02	Flat	292 52 29	6169.4	6746.7	3.83
Trepador	26 50 17.50	82 16 14.54	287 11 08	Flat	107 12 08	3807.7	4164.0	2.37
			5 06 36	Gasparilla	185 06 31	3551.1	3883.4	2.21
Boca Nueva	26 50 38.87	82 17 51.26	283 49 29	Trepador	103 50 13	2749.8	3007.1	1.71
			330 33 18	Gasparilla	150 33 56	4793.4	5241.9	2.98
Coral	26 48 58.68	82 14 57.89	65 50 01	Gasparilla	245 49 21	2664.2	2913.5	1.66
			122 47 54	Boca Nueva	302 46 36	5692.4	6225.0	3.54
Llano	26 51 04.09	82 17 23.53	342 11 11	Gasparilla	162 11 37	5200.0	5686.6	3.23
			306 58 05	Trepador	126 58 36	2383.9	2607.0	1.48
Jardella	26 47 16.93	82 12 49.46	340 07 14	Oso	160 07 17	543.4	594.2	0.34
			108 51 24	Gasparilla	288 49 46	6316.8	6907.8	3.92
Flag	26 47 22.24	82 14 13.12	117 06 14	Gasparilla	297 05 14	4119.9	4505.4	2.56
			157 23 16	Coral	337 22 56	3214.9	3515.8	2.00
Buck	26 51 59.06	82 18 40.35	308 34 52	Llano	128 35 27	2712.4	2966.2	1.69
			331 13 49	Boca Nueva	151 14 11	2815.6	3079.0	1.75
Gopher	26 51 52.13	82 18 06.10	349 42 16	Boca Nueva	169 42 23	2291.7	2506.2	1.42
			102 42 57	Buck	282 42 42	969.1	1059.8	0.60
Pine	26 52 24.25	82 18 52.41	307 42 28	Gopher	127 42 49	1615.7	1766.8	1.00
			336 45 19	Buck	156 45 24	843.5	922.4	0.52
Sand	26 49 30.43	82 10 24.97	9 02 57	Mound	189 02 52	2102.5	2299.2	1.31
			93 05 20	Flat	273 03 42	6022.5	6586.0	3.74
Mullet	26 49 12.48	82 09 45.32	43 05 22	Mound	223 04 59	2086.9	2282.1	1.30
			116 46 11	Sand	296 45 53	1226.2	1341.0	0.76
Bill	26 47 25.11	82 10 53.23	75 51 04	Oso	255 50 15	3119.9	3411.8	1.94
			194 10 52	Mound	14 10 59	1836.2	2008.0	1.14
Dana	26 51 22.25	82 09 15.32	237 22 40	Punta Gorda	57 24 25	7642.4	8357.5	4.75
			312 39 03	Torrey	132 41 38	12908.3	14116.1	8.02
Shoal Point	26 55 31.53	82 09 05 28	299 58 11	Punta Gorda	119 59 52	7110.5	7775.8	4.42
			2 04 07	Dana	182 04 02	7676.8	8395.1	4.77
Locust Point	26 55 49.91	82 07 53.83	314 31 04	Punta Gorda	134 32 13	5873.7	6423.3	3.65
			15 16 24	Dana	195 15 47	8538.7	9337.6	5.31
Eureka	26 54 55.51	82 05 39.18	114 16 03	Locust Point	294 15 02	4074.2	4455.4	2.53
			101 02 42	Shoal Point	281 01 09	5792.7	6334.8	3.60
Bruce	26 53 50.24	82 10 06.97	273 09 24	Punta Gorda	93 11 33	7874.0	8610.8	4.89
			254 46 19	Eureka	74 48 20	7656.7	8373.1	4.76
Palmetto	26 56 05.43	82 09 49.30	310 39 56	Shoal Point	130 40 16	1600.8	1750.6	0.99
			6 41 05	Bruce	186 40 57	4189.1	4581.1	2.60

GEOGRAPHICAL POSITIONS—Continued.

Section VI.—Charlotte Harbor, Fla.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Myakka	26 56 13.67	82 10 51.70	293 49 31	Shoal Point	113 50 19	3209.0	3509.2	1.99
			278 22 18	Palmetto	98 22 46	1739.7	1902.5	1.08
Grassy Point	26 57 14.06	82 05 48.77	356 26 55	Eureka	176 26 59	4272.0	4671.7	2.65
			53 06 24	Locust Point	233 05 28	4313.4	4717.0	2.68
Cooper	26 55 37.51	82 04 59.41	94 32 40	Locust Point	274 31 21	4826.5	5278.1	3.00
			155 23 02	Grassy Point	335 22 40	3268.5	3574.3	2.03
Willow Point	26 56 18.84	82 02 51.79	83 55 09	Locust Point	263 52 52	8378.9	9162.9	5.21
			70 08 38	Cooper	250 07 40	3743.0	4093.2	2.33
Live Oak	26 57 12.85	82 03 33.38	38 57 58	Cooper	218 57 19	3773.5	4126.6	2.34
			325 23 10	Willow Point	145 23 28	2019.8	2208.8	1.26
New Point	26 56 58.24	82 01 49.34	64 39 14	Cooper	244 37 49	5801.3	6344.1	3.60
			54 51 15	Willow Point	234 50 47	2106.4	2303.5	1.31
Piney Point	26 58 01.86	82 02 06.15	21 39 04	Willow Point	201 38 44	3411.3	3730.5	2.12
			57 55 00	Live Oak	237 54 20	2839.3	3105.0	1.76
Pelican	26 50 17.84	82 03 36.16	101 58 31	Dana	281 55 58	9569.8	10465.2	5.95
			154 24 35	Punta Gorda	334 23 47	6764.4	7397.3	4.20
Koonty	26 57 04.98	82 06 46.69	260 04 20	Grassy Point	80 04 46	1621.6	1773.3	1.01
			340 02 00	Punta Gorda	160 02 38	6840.1	7480.1	4.25
Alligator	26 52 24.65	82 03 26.49	121 37 27	Shoal Point	301 34 54	10975.1	12002.1	6.82
			3 55 04	Pelican	183 55 00	3911.8	4277.9	2.43
Key Point	26 47 48.29	82 03 36.12	164 43 31	Punta Gorda	344 42 43	11095.1	11095.1	6.89
			179 59 05	Pelican	359 59 05	4602.4	5033.0	2.86
Pole	26 49 56.44	82 09 03.54	303 39 29	Torrey	123 41 59	11015.3	12046.0	6.84
			265 48 44	Pelican	85 51 12	9062.0	9909.9	5.63
Mangrove Point	26 55 27.62	82 08 20.26	304 54 41	Punta Gorda	124 56 02	5996.7	6557.8	3.73
			282 31 30	Eureka	102 32 43	4552.2	4978.1	2.83
Trout	26 57 09.92	82 00 48.38	91 08 52	Live Oak Point	271 07 37	4551.5	4977.3	2.83
			126 42 13	Piney Point	306 41 38	2675.1	2925.4	1.66
Peas Creek	26 58 21.89	82 00 27.69	67 28 40	Live Oak Point	247 27 16	5544.2	6063.0	3.45
			77 13 01	Piney Point	257 12 16	2784.4	3044.9	1.73
Middle	26 57 32.25	82 00 39.05	110 46 49	Piney Point	290 46 09	2568.9	2809.2	1.60
			82 55 55	Live Oak Point	262 54 36	4844.8	5298.1	3.01

Section VII.—St. Joseph's Bay, Fla.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
CAPE ST. BLAS LIGHT	29 39 46.22	85 21 37.54						
DEAD OAK	29 41 06.25	85 16 37.10	73 03 30	Cape St. Blas light	253 01 01	8445.2	9235.4	5.25
Black's Island	29 43 37.55	85 19 38.53	313 40 36	Dead oak	133 42 06	6743.8	7374.9	4.19
			24 11 49	Cape St. Blas light	204 10 50	7807.6	8538.1	4.85
Haulover	29 40 56.80	85 19 32.11	266 26 55	Dead oak	86 28 21	4713.9	5155.0	2.93
			57 12 57	Cape St. Blas light	237 11 55	4011.8	4387.2	2.49
San Pedro	29 42 43.37	85 22 45.45	251 37 00	Black's Island	71 38 32	5293.1	5788.4	3.29
			341 29 20	Cape St. Blas light	161 29 54	5751.4	6289.5	3.57
Eagle Point	29 45 17.03	85 23 19.90	297 13 55	Black's Island	117 15 45	6690.0	7316.0	4.16
			344 52 43	Cape St. Blas light	164 53 33	10550.0	11537.2	6.56
St. Joseph	29 47 24.65	85 17 58.87	22 37 07	Cape St. Blas light	202 35 19	15288.3	16718.8	9.50
			65 31 32	Eagle Point	245 28 52	9475.5	10362.1	5.89
San Carlos	29 51 08.06	85 20 07.04	333 24 55	St. Joseph	153 25 59	7691.3	8411.0	4.78
			25 36 52	Eagle Point	205 35 16	11984.1	13105.5	7.45
St. Joseph's Point	29 51 56.65	85 23 33.82	312 56 30	St. Joseph	132 59 17	12287.4	13437.1	7.63
			285 04 20	San Carlos	105 06 03	5747.2	6285.0	3.57
Powell	29 48 07.65	85 24 30.42	277 08 58	St. Joseph	97 12 13	10597.2	11588.8	6.58
			231 49 36	San Carlos	51 51 47	8991.3	9832.6	5.59
Santa Maria de Galvez Bay, Fla.								
EMANUEL POINT 1	30 25 19.78	87 10 45.37						
GARÇON'S POINT	30 26 17.49	87 05 25.26	78 16 12	Emanuel Point 1	258 13 30	8724.2	9540.5	5.42
Redfish Point 2	30 24 00.52	87 04 42.97	104 11 11	Emanuel Point 1	284 08 07	9974.5	10907.8	6.20
			165 01 21	Garçon's Point	345 01 00	4365.6	4774.1	2.71

GEOGRAPHICAL POSITIONS—Continued.

Section VII.—Santa Maria de Galvez Bay, Fla.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
White Point 2	30 26 49.25	87 03 58.62	12 50 14	Redfish Point 2	192 49 52	5328.5	5827.1	3.31
			67 04 10	Garçon's Point	247 03 26	2510.0	2744.9	1.56
Santa Maria de Galvez	30 24 58.20	86 59 03.87	78 55 18	Redfish Point 2	258 52 26	9222.6	10085.5	5.73
			103 31 00	Garçon's Point	283 27 47	10465.3	11444.5	6.50
Escribano Point	30 30 17.55	87 01 02.86	342 06 10	Santa Maria de Galvez	162 07 10	10332.7	11299.6	6.42
			43 27 09	Garçon's Point	223 24 56	10179.3	11131.8	6.33
Miller	30 28 26.98	86 57 59.95	14 51 40	Santa Maria de Galvez	194 51 08	6650.9	7273.2	4.13
			71 28 34	Garçon's Point	251 24 48	12530.1	13702.5	7.79
East Bay	30 27 16.80	86 56 08.85	47 35 20	Santa Maria de Galvez	227 33 51	6326.2	6918.2	3.93
			83 01 29	Garçon's Point	262 56 47	14955.9	16355.4	9.29
PLANTATION HILL	30 22 08.05	87 08 37.91	150 03 13	Emanuel Point 1	330 02 08	6813.5	7451.0	4.23
Town Point 2	30 22 14.48	87 11 16.03	272 40 13	Plantation Hill	92 41 33	4226.3	4621.8	2.63
			188 09 38	Emanuel Point 1	8 09 54	5764.0	6303.4	3.58
Barkley 2	30 24 32.86	87 12 20.25	306 54 02	Plantation Hill	126 55 54	7423.2	8117.8	4.61
			338 04 54	Town Point 2	158 05 26	4592.9	5022.7	2.85
Blackwater Bay, Fla.								
Black Hammock	30 30 06.52	87 02 43.07	262 44 50	Escribano Point	82 45 41	2693.2	2945.2	1.67
			328 21 22	Santa Maria de Galvez	148 23 13	11149.5	12192.8	6.93
Barrel Stake	30 29 23.36	87 01 18.47	120 30 22	Black Hammock	300 29 39	2618.2	2863.2	1.63
			194 00 23	Escribano Point	14 00 31	1719.7	1880.6	1.07
Eagle Point	30 31 46.60	87 02 08.60	327 24 43	Escribano Point	147 25 16	3254.1	3558.6	2.02
			16 36 41	Black Hammock	196 36 23	3215.8	3516.7	2.00
Robinson's Point	30 32 52.30	87 00 49.95	4 07 49	Escribano Point	184 07 42	4777.4	5224.4	2.97
			30 34 44	Black Hammock	210 33 46	5928.8	6483.5	3.68
Catfish Lagoon	30 32 01.19	87 00 05.85	25 28 12	Escribano Point	205 27 43	3534.7	3865.4	2.20
			143 14 35	Robinson's Point	323 14 13	1964.1	2147.9	1.22
Grassy Point	30 31 23.85	87 00 40.35	174 37 45	Robinson's Point	354 37 40	2735.4	2991.3	1.70
			218 38 39	Catfish Lagoon	38 38 57	1472.3	1610.0	0.92
Woods	30 32 45.84	86 59 58.02	8 37 47	Catfish Lagoon	188 37 43	1390.5	1520.6	0.86
			98 10 38	Robinson's Point	278 10 12	1398.2	1529.1	0.87
Turtle Point	30 33 27.01	87 00 30.50	346 02 06	Catfish Lagoon	166 02 19	2722.6	2977.3	1.69
			25 52 39	Robinson's Point	205 52 29	1188.3	1299.5	0.74
Yellow Water	30 33 44.07	86 59 31.69	71 29 14	Turtle Point	251 28 44	1652.6	1807.2	1.03
			52 36 35	Robinson's Point	232 35 55	2625.5	2871.2	1.63
Bluff	30 34 39.88	86 59 46.96	27 19 56	Turtle Point	207 19 34	2526.0	2762.4	1.57
			26 52 45	Robinson's Point	206 52 13	3713.6	4061.0	2.31
Dover Wharf	30 34 16.73	87 00 00.96	26 39 31	Robinson's Point	206 39 06	2909.7	3181.9	1.81
			207 35 12	Bluff	27 35 19	804.8	880.1	0.50
Dover Mill, chimney	30 34 12.53	87 00 00.78	318 29 22	Yellow Water	138 29 37	1169.9	1279.4	0.73
			27 56 32	Robinson's Point	207 56 07	2796.6	3058.3	1.74
Pierce	30 34 24.94	87 00 10.89	313 43 42	Dover Wharf	133 43 47	366.1	400.4	0.23
			320 18 27	Yellow Water	140 18 47	1635.3	1788.3	1.02
Ward's Basin	30 34 41.42	86 59 07.04	62 06 43	Dover Wharf	242 06 16	1625.6	1777.7	1.01
			87 28 50	Bluff	267 28 30	1064.5	1164.1	0.66
Criglar	30 34 51.76	87 00 11.25	333 10 09	Yellow Water	153 10 29	2335.6	2554.1	1.45
			345 44 22	Dover Wharf	165 44 27	1113.1	1217.3	0.69
Falk	30 35 09.71	87 00 53.94	297 14 08	Bluff	117 14 42	2006.3	2194.0	1.25
			295 55 13	Criglar	115 55 35	1264.7	1383.0	0.79

Section VIII.—Chandeleur Sound, Western Coast, La.

SANDFLY	30 00 08.18	89 14 16.74						
NOWHERE	29 54 49.62	89 13 42.92	174 43 07	Sandfly	354 42 50	9850.2	10771.9	6.12
St. Bernard	29 54 47.32	89 20 04.03	223 16 48	Sandfly	43 19 41	13575.0	14845.2	8.43
			269 34 36	Nowhere	89 37 46	10222.3	11178.8	6.35
Otter Bayou	29 47 58.10	89 20 56.67	186 23 40	St. Bernard	6 24 06	12678.2	13864.5	7.88
			257 03 29	Point Comfort	77 07 21	12876.0	14080.8	8.00

GEOGRAPHICAL POSITIONS—Continued.

Section VIII.—Chandeleur Sound, Western Coast, La.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Point Chico	29 43 13.45	89 14 06.56	187 31 58	Point Comfort	7 32 27	11742.0	12840.7	7.30
			128 31 50	Otter Bayou	308 28 26	14077.4	15394.6	8.75
Blackbird	29 43 08.28	89 24 38.01	213 39 46	Otter Bayou	33 41 36	10722.5	11725.8	6.66
			269 25 10	Point Chico	89 30 23	16970.1	18558.0	10.54
Point Fortuna	29 38 54.87	89 25 16.85	202 40 08	Otter Bayou	22 42 17	18127.5	19823.7	11.26
			246 07 04	Point Chico	66 12 36	19699.7	21543.0	12.24
Fire Island	29 58 48.09	89 17 00.28	240 37 33	Sandfly	60 38 55	5029.2	5499.8	3.13
			324 12 11	Nowhere	144 13 50	9050.3	9897.1	5.62
Crane Bayou	29 58 12.95	89 15 13.23	338 49 47	Nowhere	158 50 32	6712.6	7340.7	4.17
			203 08 09	Sandfly	23 08 37	3858.0	4218.9	2.40
Picayune	29 56 39.07	89 17 00.58	214 17 15	Sandfly	34 18 37	7793.3	8522.5	4.84
			302 25 58	Nowhere	122 27 37	6281.1	6868.8	3.90
Raccoon	29 56 45.69	89 18 25.77	226 56 18	Sandfly	46 58 22	9134.0	9988.7	5.67
			295 12 23	Nowhere	115 14 44	8384.9	9169.5	5.21
Acorn Mound	29 53 00.08	89 13 42.69	179 53 52	Nowhere	359 53 52	3372.6	3688.1	2.10
			107 54 55	St. Bernard	287 51 45	10749.3	11755.1	6.68
Asses' Bridge	29 54 33.25	89 18 10.76	265 58 10	Nowhere	86 00 24	7202.0	7875.9	4.48
			211 17 52	Sandfly	31 19 49	12069.9	13199.3	7.50
Mitchell's Key	29 53 58.86	89 11 03.46	110 04 53	Nowhere	290 03 33	4553.8	4979.9	2.83
			22 18 19	Point Comfort	202 17 16	8895.7	9728.0	5.53
Carraco's house	30 01 01.09	89 15 20.96	313 25 23	Sandfly	133 25 55	2369.5	2591.2	1.47
			33 01 49	Fire Island	213 00 59	4884.0	5341.0	3.03
Copse	29 51 15.60	89 21 51.09	243 15 37	Nowhere	63 19 40	14661.7	16033.6	9.11
			203 46 34	St. Bernard	23 47 27	7123.3	7789.8	4.43
Raw Head	29 50 13.52	89 16 14.46	284 32 47	Point Comfort	104 34 19	5137.6	5618.3	3.19
			205 32 57	Nowhere	25 34 13	9424.3	10306.1	5.86
Ropeyarn	29 48 03.34	89 15 27.19	346 21 15	Point Chico	166 21 55	9184.3	10043.7	5.71
			88 58 37	Otter Bayou	268 55 53	8848.7	9676.7	5.50
New Rigolet	29 45 25.76	89 15 02.39	201 52 29	Point Comfort	21 53 25	8154.8	8917.8	5.07
			116 15 50	Otter Bayou	296 12 54	10608.4	11601.0	6.59
Codfish Point	29 45 32.42	89 18 04.01	227 03 26	Point Comfort	47 05 53	10810.9	11822.5	6.72
			303 49 39	Point Chico	123 51 37	7681.7	8400.5	4.77
Gate Island	29 44 00.90	89 19 57.07	167 38 27	Otter Bayou	347 37 57	7476.5	8176.1	4.65
			77 54 37	Blackbird	257 52 18	7720.9	8443.4	4.80
Croaker	29 41 46.83	89 22 55.53	132 19 35	Blackbird	312 18 44	3725.0	4073.6	2.31
			35 40 25	Point Fortuna	215 39 15	6516.3	7126.0	4.05
Mosquito Bight	29 46 40.22	89 23 06.96	235 34 07	Otter Bayou	55 35 12	4241.7	4638.6	2.64
			20 33 23	Blackbird	200 32 38	6968.7	7620.7	4.33
Umbrella tree	29 48 24.31	89 25 16.13	276 35 18	Otter Bayou	96 37 27	7013.4	7669.6	4.36
			353 59 24	Blackbird	173 59 43	9783.4	10698.8	6.08
Blackberry hammock	29 42 33.05	89 26 59.05	254 02 02	Blackbird	74 03 12	3942.7	4311.7	2.45
			224 10 52	Otter Bayou	44 13 52	13962.1	15268.5	8.68
Catfish Point	29 40 21.25	89 25 27.56	194 31 05	Blackbird	14 31 30	5312.1	5809.2	3.30
			353 49 01	Point Fortuna	173 49 06	2675.1	2925.4	1.66
Isle au Breton Sound, La.								
Terre aux Bœufs	29 39 47.94	89 30 37.02	237 23 30	Blackbird	57 26 28	11453.4	12525.1	7.12
			280 43 28	Point Fortuna	100 46 06	8763.3	9583.8	5.45
Black Lake	29 36 14.09	89 31 06.07	186 45 50	Terre aux Bœufs	6 46 04	6630.3	7250.7	4.12
			242 11 16	Point Fortuna	62 14 09	10617.9	11611.4	6.60
Battledore Island	29 29 03.11	89 23 42.65	138 03 15	Black Lake	317 59 36	17847.8	19517.8	11.09
			172 05 01	Point Fortuna	352 04 14	18394.1	20115.2	11.43
Plaquemines	29 29 49.72	89 30 42.68	207 33 48	Point Fortuna	27 36 29	18936.3	20708.2	11.77
			277 12 00	Battledore Island	97 15 27	11404.0	12471.1	7.09
Raccoon Point	29 24 20.67	89 27 07.67	150 15 01	Plaquemines	330 13 16	11670.0	12762.0	7.25
			212 24 57	Battledore Island	32 26 38	10302.1	11266.1	6.40
Coquille	29 23 33.81	89 21 22.50	98 50 09	Raccoon Point	278 47 20	9416.4	10297.5	5.85
			159 34 42	Battledore Island	339 33 33	10818.7	11831.0	6.72
Isle au Breton	29 27 16.87	89 13 28.28	61 47 01	Coquille	241 43 08	14509.3	15867.0	9.02
			101 13 14	Battledore Island	281 08 12	16871.1	18449.7	10.48

GEOGRAPHICAL POSITIONS—Continued.

Section VIII.—Isle au Breton Sound, La.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Bird Island, north	29 20 43.13	89 15 49.65	120 22 03	Coquille	300 19 20	10400.7	11373.9	6.46
			197 26 37	Isle au Breton	17 27 47	12706.8	13895.7	7.90
Bird Island, south	29 17 10.98	89 15 45.03	142 20 30	Coquille	322 17 45	14891.9	16285.4	9.25
			178 54 27	Bird Island, north	358 54 25	6532.5	7143.7	4.06
Jump	29 16 25.71	89 20 02.72	170 43 52	Coquille	350 43 13	13354.1	14603.7	8.30
			220 43 55	Bird Island, north	40 45 59	10461.0	11439.8	6.50
Robinson's Point	29 12 09.25	89 09 55.45	134 34 00	Bird Island, south	314 31 09	13242.7	14481.9	8.23
			148 52 45	Bird Island, north	328 49 52	18484.6	20214.2	11.49
Mississippi base, north end	29 12 08.47	89 15 16.65	176 47 05	Bird Island, north	356 46 49	15869.4	17354.3	9.86
			269 49 08	Robinson's Point	89 51 45	8675.7	9487.4	5.39
Bentley	29 38 19.98	89 28 55.71	217 57 19	Blackbird	37 59 27	11260.0	12313.6	7.00
			259 38 32	Point Fortuna	79 40 20	5983.3	6543.1	3.72
Mozambique	29 36 10.96	89 26 44.87	339 33 40	Battledore Island	159 35 10	14056.2	15371.5	8.73
			205 07 36	Point Fortuna	25 08 20	5573.9	6095.5	3.46
Curlew	29 32 12.56	89 28 51.02	305 03 41	Battledore Island	125 06 13	10147.8	11097.3	6.31
			34 22 09	Plaquemines	214 21 14	5327.2	5825.7	3.31
Julius	29 31 48.39	89 33 18.29	203 30 09	Black Lake	23 31 14	8920.6	9755.3	5.54
			311 04 26	Plauqemines	131 05 43	5559.4	6079.6	3.45
Hog Island	29 27 00.97	89 26 56.60	130 28 49	Plaquemines	310 26 58	8005.2	8754.3	4.97
			3 27 38	Raccoon Point	183 27 33	4944.2	5406.8	3.07
Quarantine, flag-staff	29 22 05.87	89 30 47.94	259 53 37	Coquille	79 58 14	15484.3	16933.2	9.62
			235 02 21	Raccoon Point	55 04 09	7245.8	7923.7	4.50
Fort Bayou	29 23 44.29	89 24 22.66	104 08 35	Raccoon Point	284 07 14	4587.0	5016.2	2.85
			186 16 02	Battledore Island	6 16 22	9874.5	10798.4	6.14
Fort St. Philip, chimney of blockhouse.	29 21 50.30	89 26 57.30	176 32 35	Raccoon Point	356 32 30	4637.7	5071.6	2.88
			229 54 09	Fort Bayou	49 55 25	5449.7	5959.6	3.39
Breton, center	29 28 22.25	89 09 09.10	37 24 11	Bird Island, north	217 20 54	17786.5	19450.8	11.05
			73 56 20	Isle au Breton	253 54 13	7266.8	7946.7	4.52
Breton, north	29 29 53.51	89 09 09.95	359 32 01	Breton, center	179 32 01	2809.9	3072.8	1.75
			55 17 46	Isle au Breton	235 15 39	8466.5	9258.7	5.26
Palmetto	29 28 02.65	89 10 22.26	33 08 07	Bird Island, north	213 05 27	16154.9	17666.6	10.04
			74 18 22	Isle au Breton	254 16 50	5206.1	5693.3	3.24
Sable Island	29 24 15.52	89 18 21.70	234 45 23	Isle au Breton	54 47 47	9680.1	10585.9	6.02
			75 15 04	Coquille	255 13 35	5040.5	5512.1	3.13
Oyster Bay	29 21 52.43	89 16 33.37	206 31 52	Isle au Breton	26 33 23	11165.1	12209.8	6.94
			29 19 50	Jump	209 18 07	11535.8	12615.2	7.17
Salt Works, chimney	29 18 11.49	89 20 35.64	238 48 18	Bird Island, north	58 50 38	9018.0	9861.8	5.60
			172 44 33	Coquille	352 44 10	10003.2	10939.2	6.22
Jamieson's Camp	29 21 20.27	89 20 48.90	278 02 25	Bird Island, north	98 04 52	8151.8	8914.6	5.00
			313 05 21	Bird Island, south	133 07 50	11229.7	12280.5	6.98
Point au Sable	29 24 10.05	89 18 17.67	18 38 17	Salt Works, chimney	198 37 09	11648.9	12738.9	7.24
			77 23 39	Coquille	257 22 08	5106.4	5584.2	3.17
Poza	29 21 37.85	89 16 31.11	46 05 36	Salt Works, chimney	226 03 36	9158.3	10015.3	5.69
			114 27 16	Coquille	294 24 53	8630.4	9437.9	5.36
Bird Island	29 17 12.87	89 15 51.03	103 14 29	Salt Works, chimney	283 12 10	7889.6	8627.9	4.90
			172 27 07	Poza	352 26 47	8229.7	8999.8	5.11
Jump 2	29 16 28.03	89 20 01.65	163 56 16	Salt Works, chimney	343 55 59	3314.7	3624.8	2.06
			258 26 46	Bird Island	78 28 49	6903.7	7549.6	4.29
Northeast Point	29 15 17.91	89 16 24.99	128 19 23	Salt Works, chimney	308 17 20	8621.0	9427.7	5.36
			194 31 08	Bird Island	14 31 25	3656.0	3998.1	2.27
Head of Woods	29 14 26.54	89 17 39.63	209 47 04	Bird Island	29 47 57	5900.4	6452.5	3.67
			231 52 19	Northeast Point	51 52 55	2561.5	2801.1	1.59
Crevasse	29 12 09.66	89 15 17.06	137 35 34	Head of Woods	317 34 24	5708.1	6242.2	3.55
			174 23 33	Bird Island	354 23 16	9379.6	10257.2	5.83
Battledore 2	29 29 02.01	89 23 44.57	315 33 20	Point au Sable	135 36 01	12585.4	13763.0	7.82
			339 14 19	Coquille	159 15 29	10805.1	11816.2	6.71
Coon Pass	29 24 22.10	89 27 01.41	211 35 56	Battledore 2	31 37 33	10119.1	11066.0	6.29
			279 13 06	Coquille	99 15 52	9256.5	10122.6	5.75
Caranero	29 20 20.73	89 18 01.65	176 30 03	Point au Sable	356 29 55	7073.0	7734.8	4.39
			137 40 25	Coquille	317 38 46	8011.8	8794.3	5.00

GEOGRAPHICAL POSITIONS—Continued.

Section VIII.—Isle au Breton Sound, La.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Donaldson's Camp	29 21 20.87	89 20 49.33	218 07 43	Point au Sable	38 08 57	6621.9	7241.5	4.11
			167 40 20	Coquille	347 40 04	4189.3	4581.3	2.60
Tiger Point	29 20 46.43	89 23 53.59	218 19 19	Coquille	38 20 33	6569.0	7183.6	4.08
			311 45 28	Salt Works, chimney	131 47 05	7160.7	7830.8	4.45
Fort Jackson, flag-staff, 1868	29 21 31.53	89 26 24.03	169 08 18	Coon Pass	349 08 00	5346.9	5847.2	3.32
			245 08 06	Coquille	65 10 34	8959.9	9798.2	5.57
Fort St. Philip, flag-staff, 1868	29 21 52.74	89 26 55.96	178 10 21	Coon Pass	358 10 18	4600.5	5030.9	2.86
			250 53 17	Coquille	70 56 01	9514.7	10404.9	5.91
Fort Bayou 2	29 23 45.44	89 24 20.37	185 39 05	Battledore 2	5 39 23	9793.8	10710.2	6.09
			104 34 58	Coon Pass	284 33 39	4485.5	4905.2	2.79
Reef Island	29 23 50.97	89 29 26.66	214 38 35	Hog Island	34 39 49	7112.4	7777.9	4.42
			256 14 23	Coon Pass	76 15 34	4031.3	4408.5	2.50
Quarantine store-house, south gable.	29 22 04.86	89 30 39.33	213 20 57	Hog Island	33 22 46	10916.5	11937.9	6.78
			234 16 02	Coon Pass	54 17 49	7236.9	7914.0	4.50
Buras Church	29 21 44.19	89 31 11.20	221 44 18	Battledore 2	41 47 57	18072.4	19763.4	11.23
			215 06 42	Hog Island	35 08 47	11925.6	13041.5	7.41
California	29 28 05.93	89 29 24.51	259 17 59	Battledore 2	79 20 46	9318.7	10190.6	5.79
			330 45 30	Coon Pass	150 46 41	7896.7	8635.6	4.91
Pelican	29 29 49.97	89 30 43.04	277 26 10	Battledore 2	97 29 36	11367.4	12431.0	7.06
			329 22 35	Coon Pass	149 24 24	11728.6	12826.0	7.29
Little Battledore	29 30 07.06	89 25 56.08	15 53 36	Hog Island	195 53 06	5955.6	6512.8	3.70
			299 28 40	Battledore 2	119 29 45	4069.1	4449.9	2.53
Long Point	29 31 24.98	89 29 34.05	32 25 21	Pelican	212 24 47	3465.0	3789.2	2.15
			295 02 24	Battledore 2	115 05 16	10390.3	11362.5	6.46
Mangrove Point	29 28 08.76	89 31 59.45	213 26 51	Pelican	33 27 29	3734.4	4083.8	2.32
			271 11 11	California	91 12 28	4175.0	4565.7	2.59
Harris' Camp	29 28 36.84	89 33 09.15	240 13 09	Pelican	60 14 21	4534.2	4958.5	2.82
			278 55 19	California	98 57 10	6125.7	6698.8	3.81
Kelly's Camp	29 26 11.11	89 31 29.45	258 11 00	Hog Island	78 13 14	7512.0	8214.9	4.67
			223 36 10	California	43 37 12	4882.3	5339.1	3.03
Bayou la Moque	28 27 07.40	89 31 22.95	152 30 06	Mangrove Point	332 29 48	2130 0	2329.3	1.32
			192 07 24	Pelican	12 07 44	5119.3	5598.3	3.18
Drake	29 32 20.34	89 32 40.05	288 46 58	Long Point	108 48 30	5289.8	5784.7	3.29
			325 45 02	Pelican	145 46 00	5600.0	6124.0	3.48
Peter Winns' hut	29 31 38.14	89 34 06.35	240 46 44	Drake	60 47 27	2661.9	2911.0	1.65
			301 17 45	Pelican	121 19 25	6408.2	7007.8	3.98
Black	29 36 14.04	89 31 05.89	344 28 14	Long Point	164 28 59	9236.2	10100.4	5.74
			19 24 33	Drake	199 23 47	7628.1	8341.9	4.74
Morgan	29 34 56.27	89 33 59.39	242 50 09	Black	62 51 35	5246.7	5737.6	3.26
			336 00 44	Drake	156 01 23	5254.1	5745.7	3.26
Little Roost	29 35 06.54	89 26 02.26	39 54 10	Long Point	219 52 26	8889.9	9721.7	5.52
			104 17 30	Black	284 15 00	8430.0	9218.8	5.24
Captain	29 33 44.31	89 29 44.08	61 23 23	Drake	241 21 56	5396.5	5901.4	3.35
			247 00 26	Little Roost	67 02 15	6484.2	7090.9	4.03
Bamboo	29 39 06.18	89 29 06.45	326 07 12	Little Roost	146 08 43	8889.9	9721.7	5.52
			31 13 16	Black	211 12 17	6201.2	6781.4	3.85
Gardener's Point	29 38 56.56	89 25 18.05	61 52 14	Black	241 49 22	10612.8	11605.9	6.59
			92 46 35	Bamboo	272 44 42	6149.2	6724.6	3.82
Bentley	29 38 19.98	89 28 55.71	168 31 20	Bamboo	348 31 15	1451.1	1586.9	0.90
			259 05 51	Gardener's Point	79 07 39	5961.0	6518.8	3.70
Terrapin	29 37 52.32	89 26 16.31	116 25 48	Bamboo	296 24 24	5110.3	5588.4	3.18
			218 22 20	Gardener's Point	38 22 49	2522.5	2758.5	1.57
Coon's Nest	29 43 29.13	89 24 21.59	10 15 51	Gardener's Point	190 15 23	8527.9	9325.8	5.30
			43 25 56	Bamboo	223 23 35	11144.2	12187.0	6.92
Grace Point	29 41 02.67	89 22 01.69	53 41 40	Gardener's Point	233 40 02	6554.9	7168.3	4.07
			140 10 51	Coon's Nest	320 09 41	5871.6	6421.0	3.65
Fiddler	29 40 57.38	89 24 07.95	26 53 49	Gardener's Point	206 53 14	4170.3	4560.5	2.59
			175 30 39	Coon's Nest	355 30 32	4686.6	5125.1	2.91
Dragon Fly	29 43 54.95	89 19 56.47	32 24 40	Grace Point	212 23 38	6282.1	6869.9	3.90
			83 39 13	Coon's Nest	263 37 02	7169.7	7840.6	4.46

GEOGRAPHICAL POSITIONS—Continued.

Section VIII.—Isle au Breton Sound, La.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Codfish Point	29 45 32.42	89 18 04.01	45 12 06	Dragon Fly	225 11 10	4258.6	4657.1	2.65
			134 04 20	Otter Bayou	314 02 54	6452.8	7056.6	4.01
Chiquito	29 43 16.44	89 14 13.73	97 21 29	Dragon Fly	277 18 39	9285.9	10154.8	5.77
			124 06 01	Codfish Point	304 04 07	7470.4	8169.4	4.64
Trimmed tree	29 46 16.30	89 18 12.35	125 24 30	Otter Bayou	305 23 08	5413.5	5920.0	3.36
			350 35 31	Codfish Point	170 35 35	1369.9	1498.1	0.85
Mississippi Delta, La.								
Head of Passes, astronomical station.	29 08 37.58	89 14 08.17	....	....				
Mississippi base, north end	29 12 08.47	89 15 16.65	344 05 18	Head of Passes, astronomical station.	164 05 51	6749.4	7381.0	4.19
Mississippi base, south end	29 09 25.79	89 13 19.81	41 22 19	Head of Passes, astronomical station.	221 21 56	1977.6	2162.6	1.23
			147 46 49	North base	327 45 52	5918.7	6472.5	3.68
Robinson's Point	29 12 09.25	89 09 55.45	47 40 55	South base	227 39 16	7471.1	8170.2	4.64
			89 51 39	North base	269 49 03	8677.5	9489.4	5.39
Head of Southeast Pass	29 09 44.51	89 09 15.42	85 01 40	South base	264 59 41	6628.9	7249.1	4.12
			166 22 56	Robinson's Point	346 22 36	4583.6	5012.4	2.85
Bird Island, south	29 17 10.98	89 15 45.03	314 31 13	Robinson's Point	134 34 04	13246.2	14485.7	8.23
			355 17 35	North base	175 17 49	9347.5	10222.1	5.81
Osgood	29 11 18.94	89 04 20.79	69 57 27	Head of Southeast Pass	249 55 03	8474.4	9267.3	5.27
			99 44 23	Robinson's Point	279 41 40	9169.4	10027.4	5.70
Balize	29 07 18.10	89 05 28.73	126 21 24	Head of Southeast Pass	306 19 34	7606.0	8317.7	4.73
			193 54 09	Osgood	13 54 42	7638.3	8353.0	4.75
Northeast Pass light	29 08 35.99	89 02 14.77	65 26 01	Balize	245 24 27	5764.8	6304.2	3.58
			145 50 28	Osgood	325 49 27	6063.0	6630.3	3.77
Pass à Loutre light	29 11 32.01	89 01 30.47	39 29 39	Balize	219 27 43	10126.8	11074.3	6.29
			12 27 38	Northeast Pass light	192 27 16	5549.3	6068.6	3.45
Blind Bay, 1857	29 09 08.05	89 00 28.75	71 00 07	Northeast Pass light	250 59 15	3030.5	3314.0	1.88
			159 22 59	Pass à Loutre light	339 22 29	4735.1	5178.2	2.94
South Mud Flat	29 10 53.67	89 00 42.35	30 30 49	Northeast Pass light	210 30 04	4919.5	5379.9	3.06
			132 14 15	Pass à Loutre light	312 13 52	1755.8	1920.0	1.09
North Mud Flat	29 11 28.29	89 00 11.96	32 02 19	Northeast Pass light	212 01 19	6256.7	6842.1	3.89
			93 05 32	Pass à Loutre light	273 04 54	2123.9	2322.7	1.32
Southeast Pass, 1857	29 04 45.61	89 02 40.08	135 50 40	Balize	315 49 18	6544.5	7156.8	4.07
			185 30 27	Northeast Pass light	5 30 39	7125.2	7791.9	4.43
Mast in wreck	29 05 02.18	89 01 30.09	122 58 54	Balize	302 56 58	7690.0	8409.6	4.78
			169 36 17	Northeast Pass light	349 35 55	6692.2	7318.4	4.16
Northeast Pass	29 07 56.31	89 01 39.66	79 15 32	Balize	259 13 41	6302.6	6892.3	3.92
			142 09 29	Northeast Pass light	322 09 12	1546.9	1691.6	0.96
South Pass light	29 01 00.25	89 09 03.36	206 30 23	Balize	26 32 07	13000.1	14216.5	8.08
			218 11 39	Northeast Pass light	38 14 58	17858.5	19529.5	11.10
Wood-yard	29 09 35.94	89 10 33.24	192 13 46	Robinson's Point	12 14 04	4828.3	5280.1	3.00
			262 50 25	Head of Southeast Pass	82 51 03	2119.3	2317.6	1.32
Mangrove Point	29 10 43.71	89 12 16.17	290 26 52	Head of Southeast Pass	110 28 20	5212.8	5700.6	3.24
			118 09 23	North base	298 07 55	5529.0	6046.3	3.44
Revenue station	29 11 13.76	89 04 40.93	69 41 11	Head of Southeast Pass	249 38 57	7908.8	8648.8	4.91
			10 05 49	Balize	190 05 26	7369.4	8059.0	4.58
Fisherman's house, chimney, or Bayou Cheval.	29 10 43.53	89 08 22.16	68 23 06	Head of Southeast Pass	218 22 40	2317.7	2534.5	1.44
			136 20 15	Robinson's Point	316 19 29	3646.8	3988.0	2.27
Jump	29 16 25.71	89 20 02.72	258 39 07	Bird Island, south	78 41 13	7095.3	7759.2	4.41
			315 41 44	North base	135 44 04	11066.1	12101.6	6.88
West Point	29 08 16.96	89 16 48.16	199 07 53	North base	19 08 38	7542.7	8248.5	4.69
			249 21 47	South base	69 23 29	6016.2	6579.2	3.74
West shore	29 11 16.42	89 15 39.24	200 52 25	North base	20 52 36	1713.4	1873.7	1.06
			312 06 26	South base	132 07 34	5078.6	5553.8	3.16
Cubitt	29 09 51.07	89 13 37.96	327 46 40	South base	147 46 49	920.2	1006.3	0.57
			147 46 40	North base	327 45 52	4998.5	5466.2	3.11
Bayou Grande	29 04 56.73	89 12 02.91	247 45 37	Balize	67 48 49	11511.5	12588.6	7.15
			165 55 04	South base	345 54 27	8540.2	9339.3	5.31

GEOGRAPHICAL POSITIONS—Continued.

Section VIII.—Mississippi Delta, La.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Telegraph station	29 09 54.14	89 14 57.97	288 12 16	South base	108 13 04	2792.4	3053.7	1.74
			330 16 11	Head of Passes, astronomical station.	150 16 35	2713.9	2967.9	1.69
Square-roofed house	29 04 24.17	89 04 34.48	164 40 53	Balize	344 40 27	5551.7	6071.2	3.45
			205 57 55	Northeast Pass light	25 59 03	8623.2	9430.1	5.36
Southeast Pass, 1859	29 04 41.59	89 02 38.57	136 20 05	Balize	316 18 43	6661.9	7285.3	4.14
			185 05 34	Northeast Pass light	5 05 46	7244.7	7922.5	4.50
Head of Passes light, 1859	29 08 36.58	89 14 07.74	164 04 31	North base	344 03 57	6782.0	7416.6	4.21
			220 32 07	South base	40 32 30	1993.2	2179.7	1.24
Osgood's observatory	29 11 19.12	89 04 21.50	13 45 42	Balize	193 45 09	7638.9	8353.6	4.75
			69 52 42	Head of Southeast Pass	249 50 19	8458.1	9249.6	5.26
Robinson, east	29 12 29.99	89 08 51.06	286 39 46	Osgood's observatory	106 41 57	7600.9	8312.1	4.72
			7 21 49	Head of Southeast Pass	187 21 37	5136.6	5617.2	3.19
Parry O'Neil	29 12 33.35	89 05 47.51	314 21 10	Osgood	134 21 52	3276.1	3582.7	2.04
			47 14 00	Head of Southeast Pass	227 12 19	7652.6	8368.6	4.76
Myer's Bayou	29 12 17.33	89 03 14.30	296 26 34	Pass à Loutre light	116 27 25	3132.6	3425.7	1.95
			44 58 52	Osgood	224 58 20	2541.1	2778.9	1.58
Middle Ground	29 12 07.44	89 01 29.74	1 02 01	Pass à Loutre light	181 02 01	1091.0	1193.1	0.68
			72 06 17	Osgood	252 04 54	4855.8	5310.1	3.02
John's Island	29 04 31.68	89 04 41.46	165 59 46	Balize	345 59 23	5280.2	5774.2	3.28
			207 47 30	Northeast Pass light	27 48 41	8502.5	9298.0	5.28
Blind Bay, 1859	29 08 49.95	89 03 44.92	280 00 08	Northeast Pass light	100 00 52	2473.7	2705.1	1.54
			44 46 40	Balize	224 45 50	3983.4	4356.1	2.47
Magazine Point	29 05 06.63	89 05 28.57	179 56 24	Balize	359 56 24	4047.4	4426.1	2.51
			279 30 23	Southeast Pass, 1859	99 31 46	4661.4	5097.5	2.90
A south	29 10 43.22	89 00 04.78	41 53 38	Northeast Pass light	221 52 35	5261.1	5753.4	3.27
			122 58 53	Pass à Loutre light	302 58 11	2759.3	3017.5	1.71
A north	29 11 31.04	88 59 59.00	6 03 23	A south	186 03 20	1480.5	1619.0	0.92
			90 41 36	Pass à Loutre light	270 40 51	2471.1	2702.3	1.54
B north	29 11 34.96	89 00 04.95	359 50 30	A south	179 50 30	1592.8	1741.9	0.99
			87 45 06	Pass à Loutre light	267 44 24	2312.0	2528.3	1.44
Pilot stake	29 08 58.69	88 59 44.86	170 30 13	A south	350 30 03	3262.2	3567.4	2.03
			175 20 28	A north	355 20 21	4760.7	5206.2	2.96
B south	29 10 31.61	89 01 14.76	167 08 25	Pass à Loutre light	347 08 17	1907.3	2085.8	1.19
			259 17 02	A south	79 17 36	1924.0	2104.1	1.20
C south	29 09 14.87	89 00 55.46	167 22 26	Pass à Loutre light	347 22 09	4326.6	4731.4	2.69
			206 43 00	A south	26 43 25	3045.3	3330.2	1.89
D south	29 10 52.00	89 00 07.57	118 49 00	Pass à Loutre light	298 48 20	2555.8	2794.9	1.59
			190 54 12	A north	10 54 16	1224.2	1338.8	0.76
E south	29 10 15.00	89 00 37.90	149 04 38	Pass à Loutre light	329 04 12	2763.4	3021.9	1.72
			225 50 35	A south	45 50 51	1247.1	1363.8	0.78
F south	29 10 52.86	89 00 26.37	124 50 29	Pass à Loutre light	304 49 58	2109.8	2307.2	1.31
			212 09 46	A north	32 09 59	1388.7	1518.6	0.86
Pass à Loutre 1	29 10 24.76	89 07 08.25	334 54 44	Balize	154 55 33	6344.6	6938.2	3.94
			70 10 47	Head of Southeast Pass	250 09 45	3652.8	3994.6	2.27
Pass à Loutre 2	29 10 31.13	89 06 11.62	348 57 29	Balize	168 57 50	6054.5	6621.0	3.76
			73 53 36	Head of Southeast Pass	253 52 06	5169.2	5652.9	3.21
Pass à Loutre 3	29 10 55.08	89 05 30.41	359 36 35	Balize	179 36 36	6679.7	7304.7	4.15
			70 21 10	Head of Southeast Pass	250 19 20	6455.8	7059.8	4.01
Pass à Loutre 4	29 11 13.98	89 02 23.61	34 34 29	Balize	214 32 59	8817.8	9642.9	5.48
			92 46 19	Osgood	272 45 22	3169.2	3465.8	1.97
Pass à Loutre 5	29 11 04.47	89 00 54.22	130 52 37	Pass à Loutre light	310 52 19	1295.1	1416.3	0.81
			241 15 31	A north	61 15 58	1701.2	1860.4	1.06
Scott's house	29 05 15.67	89 16 12.99	211 17 13	South base	31 18 37	9011.4	9854.6	5.60
			274 55 12	Bayou Grande	94 57 14	6787.6	7422.7	4.22
Willows	29 03 03.65	89 17 46.80	211 57 53	Scott's house	31 58 39	4791.5	5239.8	2.98
			249 27 36	Bayou Grande	69 30 23	9930.7	10859.9	6.17
Grand Pass	29 00 22.82	89 12 28.82	119 56 29	Willows	299 53 55	9926.1	10854.9	6.17
			184 45 01	Bayou Grande	4 45 14	8460.7	9252.4	5.26

GEOGRAPHICAL POSITIONS—Continued.

Section VIII.—Mississippi Delta, La.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Pilot's Lookout	28 59 53.88	89 19 49.95	210 37 47	Scott's house	30 39 32	11514.7	12592.1	7.15
			265 42 10	Grand Pass	85 45 44	11971.3	13091.4	7.44
Southwest Pass light	28 58 52.86	89 22 20.39	220 07 11	Scott's house	40 10 09	15417.0	16859.6	9.58
			223 46 46	Willows	43 48 59	10696.2	11697.1	6.65
Telegraph pole, 1866	29 09 43.00	89 14 55.49	281 34 10	South base	101 34 57	2639.2	2886.2	1.64
			14 17 16	Scott's house	194 16 38	8492.0	9286.6	5.28
Scott's Point	29 06 01.82	89 19 24.28	285 20 42	Scott's house	105 22 15	5363.8	5865.7	3.33
			334 19 28	Willows	154 20 15	6085.9	6655.4	3.78
Fisherman's house, chimney	29 06 39.15	89 15 05.91	35 13 16	Scott's house	215 12 43	3145.4	3439.7	1.95
			302 30 07	Bayou Grande	122 31 36	5867.5	6416.5	3.65
Double Bayou	29 03 42.57	89 19 32.35	241 59 23	Scott's house	62 01 00	6105.8	6677.1	3.79
			292 45 59	Willows	112 46 50	3096.1	3385.8	1.92
Thirty-second telegraph pole	29 01 41.42	89 19 18.42	217 14 13	Scott's house	37 15 43	8286.2	9061.6	5.15
			242 56 03	Bayou Grande	62 59 35	13225.4	14462.9	8.22
Custom-house	29 00 27.82	89 19 30.27	270 44 42	Grand Pass	90 48 06	11405.9	12473.2	7.09
			27 01 06	Pilot's Lookout	207 00 56	1172.8	1282.6	0.73
Alex. Pitcarn's chimney	29 00 34.57	89 20 09.63	336 57 32	Pilot's Lookout	156 57 41	1361.3	1488.6	0.85
			48 30 33	Southwest Pass light	228 29 30	4725.4	5167.5	2.94
Fred. Martin's house, east gable	29 00 18.20	89 20 25.66	307 46 01	Pilot's Lookout	127 46 18	1222.6	1337.0	0.76
			49 46 36	Southwest Pass light	229 45 40	4067.7	4448.3	2.53
Lookout telegraph station	28 59 48.91	89 20 55.52	265 04 31	Pilot's Lookout	85 05 03	1781.3	1948.0	1.11
			53 05 34	Southwest Pass light	233 04 53	2873.1	3141.9	1.79
East Point	28 58 20.51	89 20 49.25	111 59 17	Southwest Pass light	291 58 34	2660.6	2909.6	1.65
			209 10 47	Pilot's Lookout	29 11 15	3292.2	3600.2	2.05
East Mud Lump	28 55 59.29	89 21 57.63	173 25 25	Southwest Pass light	353 25 14	5378.3	5881.6	3.34
			205 34 20	Pilot's Lookout	25 35 22	8006.1	8755.3	4.97
Barber-pole buoy	28 56 10.85	89 23 50.38	223 27 24	Pilot's Lookout	43 29 20	9460.6	10345.9	5.88
			206 01 48	Southwest Pass light	26 02 32	5550.4	6069.7	3.45
Atchafalaya Bay.								
Deer Island	29 28 46.70	91 15 03.00	....	....	....	....	....	....
Point au Fer light	29 19 50.85	91 20 09.57	206 35 16	Deer Island	26 37 46	18451.4	20177.9	11.46
Belle Isle	29 31 25.16	91 23 10.18	290 21 44	Deer Island	110 25 44	13998.1	15307.9	8.70
			347 09 33	Point au Fer light	167 11 02	21922.8	23974.2	13.62
Ballast Ground 2	29 26 40.06	91 29 52.45	308 40 38	Point au Fer light	128 45 24	20141.7	22026.4	12.51
			230 57 48	Belle Isle	51 01 06	13944.8	15249.6	8.66
Marshy shore	29 32 20.34	91 27 11.96	284 36 34	Belle Isle	104 38 33	6727.6	7357.1	4.18
			22 26 00	Ballast Ground 2	202 24 41	11333.0	12393.4	7.04
Point Chevreuil	29 30 45.33	91 33 08.32	325 02 40	Ballast Ground 2	145 04 17	9211.9	10073.9	5.72
			253 01 19	Marshy shore	73 04 15	10030.9	10969.5	6.23
Middle shoal	29 28 37.65	91 31 34.96	225 50 16	Marshy shore	45 52 25	9843.7	10764.7	6.12
			147 12 23	Point Chevreuil	327 11 37	4676.4	5114.0	2.91
East base	29 31 08.45	91 31 02.04	78 11 11	Point Chevreuil	258 10 09	3474.2	3799.3	2.16
			10 35 29	Middle shoal	190 35 13	4723.0	5164.9	2.93
Four League Bay	29 22 14.61	91 14 13.69	173 43 15	Deer Island	353 42 51	12144.0	13280.3	7.55
			65 16 07	Point au Fer light	245 13 13	10569.9	11558.9	6.57
Point Necessity	29 19 19.92	91 16 20.79	99 08 16	Point au Fer light	279 06 28	6005.3	6567.2	3.73
			214 18 18	Four League Bay	34 19 25	6511.6	7120.8	4.05
South base	29 17 00.83	91 18 48.83	157 24 24	Point au Fer light	337 23 45	5669.3	6199.8	3.52
			221 13 01	Point Necessity	41 14 09	5693.2	6225.9	3.54
Middle base	29 17 42.95	91 19 33.20	166 00 20	Point au Fer light	346 00 02	4059.1	4439.0	2.52
			317 17 19	South base	137 17 41	1766.2	1931.5	1.10
Center signal 1	29 25 59.04	91 23 43.82	249 46 13	Deer Island	69 50 29	14951.7	16350.8	9.29
			185 09 16	Belle Isle	5 09 32	10081.0	11024.3	6.26
Center signal 2	29 26 00.07	91 23 44.90	97 06 32	Ballast Ground 2	277 03 31	9980.9	10914.8	6.20
			185 20 12	Belle Isle	5 20 29	10052.0	10992.6	6.25
Ballast Ground 1	29 26 40.07	91 29 52.20	230 56 48	Belle Isle	51 00 05	13939.3	15243.6	8.66
			308 41 25	Point au Fer light	128 46 11	20136.6	22020.8	12.51
Atchafalaya west	29 28 22.03	91 16 13.24	248 07 34	Deer Island	68 08 09	2038.7	2229.4	1.27
			22 03 21	Point au Fer light	202 01 25	16978.0	18566.6	10.55

GEOGRAPHICAL POSITIONS—Continued.

Section VIII.—Atchafalaya Bay, La.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Plum Island	29 26 48.97	91 14 31.66	166 38 50	Deer Island	346 38 34	3725.3	4073.9	2.31
			136 09 09	Atchafalaya west	316 08 19	3973.3	4345.1	2.47
Shell Key	29 22 36.72	91 24 47.63	304 14 04	Point au Fer light	124 16 20	9073.4	9922.4	5.64
			195 26 02	Center signal 1	15 26 33	6462.0	7066.7	4.02
East Bay	29 29 37.77	91 20 20.44	125 53 28	Belle Isle	305 51 56	5641.5	6169.3	3.51
			280 23 50	Deer Island	100 26 26	8693.9	9507.4	5.40
Schooner Reef	29 25 49.96	91 34 58.87	259 24 03	Ballast Ground 2	79 26 34	8400.3	9186.3	5.22
			198 07 40	Point Chevreuil	18 08 34	9568.7	10464.0	5.95
Bird Key	29 30 14.40	91 37 14.36	261 48 19	Point Chevreuil	81 50 20	6693.9	7320.3	4.16
			335 50 32	Schooner Reef	155 51 39	8922.0	9756.8	5.54
Rabbit Island	29 30 16.45	91 34 54.91	252 47 02	Point Chevreuil	72 47 55	3005.0	3286.2	1.87
			299 21 32	Middle Shoal	119 23 11	6201.5	6781.7	3.85
Southwest Reef	29 28 18.93	91 37 45.17	315 39 17	Schooner Reef	135 40 39	6411.9	7011.9	3.98
			193 08 23	Bird Key	13 08 38	3650.5	3992.0	2.27
Beacon	29 23 33.14	91 29 11.37	169 06 38	Ballast Ground 2	349 06 18	5860.0	6408.3	3.64
			114 14 12	Schooner Reef	294 11 21	10270.6	11231.7	6.38
Lightship, 1856	29 23 12.26	91 27 57.69	154 12 07	Ballast Ground 2	334 11 11	7106.1	7771.0	4.42
			113 10 54	Schooner Reef	293 07 27	12348.1	13503.5	7.67
Oyster Reef, A	29 23 04.41	91 23 49.81	181 43 14	Center signal 1	1 43 17	5378.8	5882.1	3.34
			315 04 40	Point au Fer light	135 06 28	8413.6	9200.8	5.23
Barrel stake 1	29 25 16.25	91 29 46.67	176 32 24	Ballast Ground 2	356 32 21	2584.7	2826.5	1.61
			97 03 09	Schooner Reef	277 00 36	8478.3	9271.6	5.27
Barrel stake, Anne Channel	29 23 47.31	91 26 09.89	224 08 36	Center signal 1	44 09 48	5652.4	6181.3	3.51
			314 24 35	Shell Key	134 25 15	3105.2	3395.8	1.93
Lightship, 1855	29 24 21.80	91 29 42.03	298 19 24	Point au Fer light	118 24 05	17553.0	19195.5	10.91
			252 44 55	Center signal 1	72 47 51	10099.0	11044.0	6.27
Côte Blanche Bay.								
Côte Blanche, red chimney	29 34 08.50	91 32 07.69	14 37 39	Point Chevreuil	194 37 09	6464.6	7069.5	4.02
			48 54 05	Bird Key	228 51 34	10959.5	11985.0	6.81
Bird Key 2	29 30 14.50	91 37 15.17	287 57 50	Middle Shoal	108 00 38	9654.5	10557.8	6.00
			261 51 20	Point Chevreuil	81 53 22	6714.9	7343.3	4.17
Point No Point	29 37 27.04	91 36 35.13	335 45 22	Point Chevreuil	155 47 04	13562.5	14831.5	8.43
			4 37 44	Bird Key 2	184 37 24	13360.6	14610.8	8.30
Marsh Island north	29 34 49.63	91 40 56.72	324 50 03	Bird Key 2	144 51 52	10359.9	11329.3	6.44
			235 25 50	Point No Point	55 28 00	8545.4	9345.0	5.31
Malony's Point	29 37 47.08	91 38 44.44	280 03 07	Point No Point	100 04 11	3532.6	3863.1	2.19
			33 05 20	Marsh Island north	213 04 15	6520.5	7130.6	4.05
Gordy	29 37 21.26	91 32 08.67	7 30 23	Point Chevreuil	187 29 54	12295.0	13445.5	7.64
			91 26 27	Point No Point	271 24 16	7169.6	7840.5	4.46
Burns	29 34 37.16	91 31 26.12	21 05 09	Point Chevreuil	201 04 19	7649.4	8365.2	4.75
			122 11 39	Point No Point	302 09 06	9822.2	10741.3	6.10
Rabbit Island north	29 30 30.11	91 35 07.91	82 01 21	Bird Key 2	262 00 18	3460.9	3784.7	2.15
			320 15 02	Rabbit Island	140 15 08	547.0	598.2	0.34
Stephens	29 25 12.77	91 33 55.38	149 55 21	Bird Key 2	329 53 43	10760.9	11767.8	6.69
			170 16 07	Rabbit Island	350 15 38	9508.0	10397.6	5.91
Marsh Island east	29 32 07.41	91 43 01.06	290 26 40	Bird Key 2	110 29 31	9941.0	10871.2	6.18
			213 48 53	Marsh Island north	33 49 54	6011.8	6574.4	3.74
Mosquito	29 35 29.10	91 44 51.98	246 43 27	Malony's Point	66 46 29	10761.5	11768.4	6.69
			280 51 07	Marsh Island north	100 53 03	6445.9	7049.1	4.00
Lake Point	29 34 16.08	91 42 26.82	246 55 16	Marsh Island north	66 56 00	2635.1	2881.7	1.64
			119 55 49	Mosquito	299 54 37	4507.0	4928.8	2.80
Dry Shoal	29 35 42.45	91 43 28.53	243 19 10	Malony's Point	63 21 30	8551.6	9351.7	5.31
			291 41 57	Marsh Island north	111 43 12	4396.5	4807.9	2.73
Shell Key	29 35 38.09	91 43 19.01	241 42 53	Malony's Point	61 45 09	8386.3	9171.0	5.21
			291 16 53	Marsh Island north	111 18 03	4108.9	4493.3	2.55
Côte Blanche	29 44 07.71	91 41 51.29	336 47 10	Malony's Point	156 48 42	12749.5	13942.5	7.92
			16 56 15	Mosquito	196 54 45	16689.4	18251.0	10.37
Bayou Franklin	29 44 19.39	91 37 05.61	12 24 48	Malony's Point	192 23 59	12366.9	13524.0	7.68
			87 20 14	Côte Blanche	267 17 52	7684.1	8403.1	4.77
Main shore 2	29 41 51.10	91 36 36.04	24 41 28	Malony's Point	204 40 24	8268.1	9041.8	5.14
			116 25 22	Côte Blanche	296 22 46	9458.4	10343.4	5.88

GEOGRAPHICAL POSITIONS—Continued.

Section VIII.—Côte Blanche Bay.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Main shore 1	29 40 39.29	91 36 42.62	127 44 31	Côte Blanche	307 41 58	10488.0	11469.3	6.52
			184 34 19	Main shore 2	4 34 22	2218.0	2425.5	1.38
Sugar-house, small white chimney.	29 44 55.24	91 41 36.00	340 42 23	Malony's Point	160 43 48	13965.1	15271.8	8.68
			16 50 04	Mosquito	196 48 27	18209.0	19912.8	11.31
Sugar-house, red chimney	29 44 54.95	91 41 35.43	340 45 14	Malony's Point	160 46 39	13951.8	15257.3	8.67
			16 53 19	Mosquito	196 51 42	18205.1	19908.6	11.31
Tall white chimney	29 44 54.62	91 41 34.12	340 52 36	Malony's Point	160 54 00	13930.5	15233.9	8.66
			17 00 15	Mosquito	196 58 37	18205.4	19908.9	11.31
Dwelling-house, chimney	29 44 25.87	91 42 03.59	336 25 34	Malony's Point	156 27 13	13393.7	14646.9	8.32
			15 19 59	Mosquito	195 18 36	17135.2	18738.6	10.65
Baker	29 43 56.69	91 46 45.81	267 31 28	Côte Blanche	87 33 54	7921.1	8662.3	4.92
			348 54 36	Mosquito	168 55 32	15924.1	17414.1	9.89
Beverly	29 37 29.57	91 49 07.40	223 41 45	Côte Blanche	43 45 21	16962.3	18549.4	10.54
			298 20 18	Mosquito	118 22 24	7808.7	8539.3	4.85
Dead cypress	29 41 45.48	91 51 05.26	338 04 50	Beverly	158 05 48	8492.5	9287.1	5.28
			253 34 18	Côte Blanche	73 38 52	15518.4	16970.5	9.64
Catesby	29 36 33.59	91 46 54.86	144 58 42	Dead cypress	324 56 38	11728.1	12825.5	7.29
			210 15 15	Côte Blanche	30 17 45	16189.5	17704.4	10.06
Water station	29 41 04.23	91 47 00.18	184 09 31	Baker	4 09 38	5323.6	5821.7	3.31
			235 44 45	Côte Blanche	55 47 18	10041.4	10980.9	6.24
Oak tree	29 44 55.08	91 41 58.56	76 54 30	Baker	256 52 07	7924.4	8665.9	4.92
			352 21 48	Côte Blanche	172 21 52	1471.3	1608.9	0.91
Point Gracious	29 38 34.93	91 52 59.79	287 49 46	Beverly	107 51 41	6566.3	7180.7	4.08
			207 41 09	Dead cypress	27 42 06	6625.8	7245.7	4.12
Needle Point	29 38 09.57	91 50 37.87	296 50 06	Beverly	116 50 51	2727.3	2982.5	1.69
			173 40 51	Dead cypress	353 40 37	6688.2	7314.0	4.16
Sallie Island	29 39 26.48	91 51 15.67	316 12 27	Beverly	136 13 30	4985.6	5452.1	3.10
			183 44 27	Dead cypress	3 44 32	4288.8	4690.1	2.66
Station B	29 36 29.99	91 48 18.70	155 15 15	Dead cypress	335 13 53	10696.2	11697.1	6.65
			144 28 29	Beverly	324 28 05	2254.3	2465.2	1.40
Isle au Breton Sound, eastern side.								
Breton	29 27 56.42	89 11 46.34	33 23 17	Poza	213 20 57	13955.3	15261.1	8.67
			56 34 06	Point au Sable	236 30 54	12640.6	13823.4	7.85
Breton Break	29 28 42.66	89 08 48.97	43 38 06	Poza	223 34 19	18060.8	19750.8	11.22
			73 25 15	Breton	253 23 48	4985.8	5452.3	3.10
North Point	29 29 54.16	89 09 18.89	339 53 29	Breton Break	159 53 44	2344.0	2563.3	1.46
			47 37 34	Breton	227 36 21	5377.3	5880.5	3.34
Date	29 28 02.62	89 10 22.31	85 11 03	Breton	265 10 22	2272.4	2485.0	1.41
			206 26 39	North Point	26 27 10	3835.9	4194.9	2.38
Myth	29 35 04.35	89 00 20.87	49 22 22	Breton Break	229 18 12	18034.0	19721.5	11.21
			56 38 20	North Point	236 33 55	17349.0	18972.3	10.78
Levee	29 36 02.12	88 58 50.02	53 57 59	Myth	233 57 14	3023.1	3306.0	1.88
Turtle	29 37 08.13	88 59 26.43	21 01 39	Myth	201 01 12	4082.7	4464.8	2.54
			334 15 53	Levee	154 16 11	2256.0	2467.1	1.40
Lagoon	29 37 26.23	88 57 10.21	81 21 49	Turtle	261 20 42	3706.5	4053.3	2.30
			46 02 47	Levee	226 01 58	3730.4	4079.4	2.32
Curlew	29 38 03.42	88 57 23.97	31 47 53	Levee	211 47 10	4394.1	4805.3	2.73
			342 04 51	Lagoon	162 04 58	1203.4	1316.0	0.75
Camp	29 38 51.13	88 55 43.46	43 58 36	Levee	223 57 04	7229.1	7905.6	4.49
			61 29 07	Curlew	241 28 17	3076.1	3364.0	1.91
Sand Reef	29 39 51.96	88 55 18.10	45 22 41	Curlew	225 21 39	4756.4	5201.5	2.96
			20 01 02	Camp	200 00 49	1993.0	2179.5	1.24
Stake Island	29 40 50.55	88 53 54.25	51 20 12	Sand Reef	231 19 31	2887.0	3157.2	1.79
			38 37 17	Camp	218 36 23	4705.2	5145.5	2.92

GEOGRAPHICAL POSITIONS—Continued.

Section X.—Coast from Santa Cruz to Point Ano Nuevo, Cal.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
ST. JOHN'S HILL	36 58 28.48	122 04 32.68						
MOORE	36 56 45.40	122 02 55.32	142 50 51	St. John's Hill	322 49 53	3986.8	4359.8	2.48
BALCRAFT 1	36 57 08.76	122 04 31.33	179 13 22	St. John's Hill	359 13 21	2457.5	2687.4	1.53
			286 51 20	Moore	106 52 18	2481.9	2714.2	1.54
Parsons	36 57 38.66	122 06 06.96	291 16 53	Balcraft 1	111 17 51	2538.8	2776.3	1.58
			236 37 40	St. John's Hill	56 38 37	2792.0	3053.3	1.73
Rico	36 58 39.90	122 05 49.73	12 43 17	Parsons	192 43 07	1935.0	2116.1	1.20
			280 27 35	St. John's Hill	100 28 21	1937.8	2119.1	1.20
Lagoon	36 58 27.20	122 08 08.26	296 29 33	Parsons	116 30 46	3352.5	3666.2	2.08
			263 28 08	Rice	83 29 31	3448.1	3770.8	2.14
Butler	36 59 21.17	122 07 24.04	33 18 48	Lagoon	213 18 21	1990.8	2177.1	1.24
			298 36 19	Rice	118 37 16	2656.7	2905.3	1.65
Glassell	36 59 48.55	122 09 57.55	312 50 42	Lagoon	132 51 48	3687.0	4032.0	2.29
			282 31 19	Butler	102 32 51	3888.5	4252.4	2.42
Redwood	37 01 57.85	122 08 59.77	19 42 48	Glassell	199 42 13	4233.6	4629.7	2.63
			333 52 51	Butler	153 53 49	5378.4	5881.7	3.34
Point	37 01 22.04	122 12 21.12	309 03 41	Glassell	129 05 07	4571.7	4999.5	2.84
			257 28 25	Redwood	77 30 26	5096.8	5573.7	3.17
Mansinita	37 02 34.62	122 11 26.56	31 04 09	Point	211 03 36	2611.8	2856.2	1.62
			287 20 12	Redwood	107 21 40	3800.4	4156.0	2.36
Cook	37 03 39.38	122 13 23.54	339 58 05	Point	159 58 43	4506.0	4927.7	2.80
			304 37 22	Mansinita	124 38 32	3512.7	3841.4	2.18
Pine	37 05 21.12	122 12 08.25	30 40 16	Cook	210 39 31	3645.8	3986.9	2.26
			348 38 52	Mansinita	168 39 17	5234.6	5724.4	3.25
Tranta	37 05 37.44	122 15 05.05	325 25 39	Cook	145 26 40	4419.0	4832.4	2.75
			276 33 28	Pine	96 35 15	4394.5	4805.7	2.73
Steele	37 08 03.44	122 15 55.52	344 39 37	Tranta	164 31 07	4670.0	5107.0	2.90
			311 42 13	Pine	131 44 30	7517.9	8221.3	4.67
Point Ano Nuevo	37 06 42.46	122 18 49.04	289 54 01	Tranta	109 56 16	5882.7	6433.2	3.66
			239 44 55	Steele	59 46 40	4957.0	5420.9	3.08
Gushee	37 09 38.32	122 17 51.52	14 40 25	Point Ano Nuevo	194 39 50	5603.5	6127.8	3.48
			315 36 20	Steele	135 37 30	4092.4	4475.3	2.54
Middle Point	37 08 51.13	122 20 35.86	326 22 30	Point Ano Nuevo	146 23 35	4762.7	5208.4	2.96
			250 15 00	Gushee	70 16 39	4307.6	4710.6	2.68
North gable of old house	36 57 22.60	122 04 03.11	160 11 28	St. John's Hill	340 11 10	2158.2	2360.2	1.34
			132 06 12	Rice	312 05 08	3554.0	3886.6	2.21
Balcraft's Landing, flag-staff	36 57 03.59	122 04 11.01	168 25 19	St. John's Hill	348 25 06	2670.7	2920.6	1.66
			110 39 29	Parsons	290 38 19	3065.2	3352.0	1.90
Barn, west gable	36 57 31.54	122 04 49.52	96 32 50	Parsons	276 32 03	1928.1	2108.6	1.20
			327 20 56	Balcraft 1	147 21 07	833.9	912.0	0.52
Cutts No. 1	36 58 50.80	122 05 42.79	27 02 53	Rice	207 02 49	377.3	412.6	0.23
			291 38 16	St. John's Hill	111 38 58	1865.5	2040.0	1.16
Cutts No. 2	36 57 57.87	122 07 00.89	293 56 03	Parsons	113 56 35	1459.5	1596.1	0.91
			255 33 23	St. John's Hill	75 34 52	3785.0	4139.2	2.35
Dunlap's house, chimney	36 58 13.65	122 06 43.40	101 15 27	Lagoon	281 14 36	2139.8	2340.0	1.33
			320 06 38	Parsons	140 07 00	1405.6	1537.1	0.87
Topog. No. 1	36 59 11.05	122 09 06.49	313 10 35	Lagoon	133 11 10	1975.2	2160.0	1.23
			262 58 04	Butler	82 59 06	2552.5	2791.3	1.59
Topog. No. 2	37 00 43.05	122 11 19.45	236 14 42	Redwood	56 16 06	4151.0	4539.4	2.58
			177 03 40	Mansinita	357 03 36	3443.5	3765.7	2.14
Topog. No. 3	37 01 50.60	122 12 36.85	231 59 31	Mansinita	52 00 13	2203.8	2410.1	1.37
			161 00 35	Cook	341 00 07	3546.0	3877.8	2.20
Topog. No. 4	37 03 12.23	122 13 33.16	331 03 01	Topog. No. 3	151 03 35	2875.2	3144.2	1.79
			195 49 43	Cook	15 49 49	869.9	951.3	0.54
Topog. No. 5	37 04 12.13	122 14 24.47	303 50 38	Cook	123 51 15	1812.1	1981.7	1.13
			159 08 27	Tranta	339 08 02	2814.2	3077.5	1.75
Topog. No. 6	37 06 40.62	122 17 04.78	168 06 26	Gushee	348 05 58	5597.7	6121.4	3.48
			91 16 03	Point Ano Nuevo	271 15 00	2574.4	2815.3	1.60
Topog. No. 7	37 08 16.07	122 19 33.74	224 50 28	Gushee	44 51 30	3575.9	3910.5	2.22
			125 11 02	Middle Point	305 10 25	1875.5	2051.0	1.17

GEOGRAPHICAL POSITIONS—Continued.

Section X.—Coast from Santa Cruz to Point Ano Nuevo, Cal.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Topog. No. 8	37 10 09.95	122 20 58.40	347 06 34	Middle Point	167 06 48	2492.6	2725.8	1.55
			281 55 42	Gushee	101 57 35	4711.9	5152.8	2.93
Barn No. 2, north gable	36 58 06.25	122 05 37.37	163 34 42	Rice	343 34 35	1081.2	1182.4	0.67
			40 42 49	Parsons	220 42 31	1121.9	1226.9	0.70
Rice's house, chimney	36 58 01.10	122 05 57.23	188 48 27	Rice	8 48 32	1210.2	1323.4	0.75
			19 11 43	Parsons	199 11 37	732.3	800.8	0.45
Gushee's house, south chimney	37 08 50.92	122 19 43.50	341 14 44	Point Ano Nuevo	161 15 17	4181.8	4573.1	2.60
			284 33 52	Steele	104 36 10	5812.9	6356.8	3.61
Waddell's wharf, east pier	37 06 49.63	122 17 45.75	299 16 06	Tranta	119 17 43	4549.5	4975.2	2.83
			230 04 56	Steele	50 06 03	3546.5	3878.3	2.20
Coast from Point Ano Nuevo to Halfmoon Bay, Cal.								
PISE HILL	37 27 34.58	122 19 37.31	....	....	....	....	....	....
JOHNSTON	37 26 10.47	122 25 28.44	253 14 46	Pise Hill	73 18 19	9010.6	9853.8	5.60
HALFMOON BAY	37 29 09.87	122 24 54.93	290 35 58	Pise Hill	110 39 11	8337.9	9118.0	5.18
			8 28 12	Johnston	188 27 51	5591.1	6114.2	3.47
Summit	37 25 30.31	122 20 54.35	100 25 53	Johnston	280 23 06	6850.5	7491.5	4.26
			138 52 53	Halfmoon Bay	318 50 27	8986.7	9827.6	5.58
Sellick	37 23 54.47	122 23 20.62	143 09 13	Johnston	323 07 55	5239.7	5730.0	3.26
			230 34 37	Summit	50 36 06	4654.3	5089.8	2.89
Wetner	37 22 01.40	122 23 10.36	207 26 14	Summit	27 27 36	7256.8	7935.8	4.51
			156 09 15	Johnston	336 07 51	8395.1	9180.6	5.22
Pillar Point	37 29 45.31	122 28 53.69	280 31 59	Halfmoon Bay	100 34 24	5965.5	6523.7	3.71
			322 41 35	Johnston	142 43 40	8324.4	9103.3	5.17
Denniston	37 31 21.38	122 26 46.89	325 50 37	Halfmoon Bay	145 51 45	4898.4	5356.8	3.04
			46 26 51	Pillar Point	226 25 34	4297.1	4699.2	2.67
Hogle	37 31 46.45	122 29 47.94	279 51 01	Denniston	99 52 52	4511.6	4933.7	2.80
			340 21 51	Pillar Point	160 22 24	3964.8	4335.7	2.46
Peak Mountain	37 33 35.79	122 27 49.70	12 28 24	Pillar Point	192 27 45	7276.5	7957.4	4.52
			40 44 20	Hogle	220 43 08	4447.8	4863.9	2.76
Piedra	37 34 24.24	122 29 42.59	352 02 58	Pillar Point	172 03 28	8681.9	9494.3	5.39
			1 32 49	Hogle	181 32 46	4865.9	5321.2	3.02
South Peak	87 33 12.26	122 27 45.59	337 08 20	Denniston	157 08 56	3709.1	4056.2	2.30
			127 42 44	Piedra	307 41 33	3628.6	3968.1	2.25
Cattle Hill	37 36 17.79	122 27 55.80	358 17 03	Peak Mountain	178 17 07	4996.1	5463.6	3.10
			36 49 09	Piedra	216 48 04	4372.0	4781.1	2.72
False Cattle Hill	37 36 41.00	122 28 42.32	347 15 25	Peak Mountain	167 57	5853.4	6401.1	3.64
			19 19 49	Piedra	199 12	4467.4	4885.4	2.78
Wetner 2	37 20 26.80	122 22 19.02	156 16 32	Johnston	336 14 36	11573.2	12656.1	7.19
			192 32 18	Summit	12 33 10	9585.1	10482.0	5.96
Seal	37 23 26.61	122 24 20.29	232 59 47	Summit	53 01 52	6339.1	6932.3	3.94
			331 41 37	Wetner 2	151 42 51	6294.7	6883.6	3.91
Hamilton	37 20 22.23	122 19 59.05	92 21 22	Wetner 2	272 19 57	3448.1	3770.8	2.14
			171 50 53	Hamilton	351 50 19	9594.4	10492.1	5.96
Peak	37 17 37.45	122 20 35.98	154 05 12	Wetner 2	334 04 09	5804.6	6347.7	3.61
			190 08 28	Hamilton	10 08 50	5160.2	5643.0	3.21
Gilbert	37 21 25.72	122 20 01.17	6 56 27	Peak	186 56 06	7088.5	7751.8	4.40
			61 51 00	Wetner 2	241 49 36	3847.9	4207.9	2.39
Pescadero	37 16 22.32	122 23 13.04	190 00 01	Wetner 2	10 00 33	7652.7	8368.8	4.76
			239 04 54	Peak	59 06 29	4508.7	4930.6	2.80
Beutro	37 13 29.25	122 19 34.39	134 44 05	Pescadero	314 41 53	7582.4	8291.9	4.71
			168 47 09	Peak	348 46 32	7799.7	8529.5	4.85
Young	37 12 15.15	122 22 03.60	167 20 37	Pescadero	347 19 55	7809.0	8539.6	4.85
			192 15 07	Peak	12 16 00	10166.7	11118.0	6.32
Ranch	37 11 05.95	122 21 19.02	152 44 05	Young	332 43 38	2399.7	2624.2	1.49
			210 16 22	Beutro	30 17 25	5115.1	5593.7	3.18
Pigeon Point	37 10 46.00	122 22 36.91	196 37 59	Young	16 38 19	2868.0	3136.3	1.78
			252 14 32	Ranch	72 15 19	2016.9	2205.6	1.25
Bolsa	37 11 37.09	122 23 13.93	288 42 10	Ranch	108 43 19	2992.2	3272.2	1.86
			329 52 58	Pigeon Point	149 53 20	1820.6	1991.0	1.13

GEOGRAPHICAL POSITIONS—Continued.

Section X.—Coast from Point Ano Nuevo to Halfmoon Bay, Cal.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Purcell's flag-staff	37 24 06.25	122 24 09.33	286 51 04	Sellick	106 51 34	1252.1	1369.3	0.78
			12 25 53	Seal	192 25 46	1251.3	1368.4	0.78
Flora	37 23 18.60	122 23 12.18	98 23 19	Seal	278 22 38	1693.4	1851.8	1.05
			169 22 17	Sellick	349 22 12	1125.1	1230.4	0.70
Barley	37 22 33.43	122 22 34.63	122 15 02	Seal	302 13 58	3072.7	3360.3	1.91
			155 38 48	Sellick	335 38 20	2742.2	2998.8	1.70
Tunitas	37 21 19.31	122 22 18.36	266 38 18	Gilbert	86 39 41	3381.5	3697.9	2.10
			0 34 35	Wetner 2	180 34 35	1618.5	1769.9	1.01
Last	37 21 34.65	122 23 09.64	273 22 56	Gilbert	93 24 50	4645.6	5080.3	2.89
			329 13 01	Wetner 2	149 13 32	2434.3	2662.1	1.51
Accident	37 16 58.62	122 22 20.37	180 17 27	Wetner 2	0 17 28	6417.4	7017.9	3.99
			208 59 21	Hamilton	29 00 47	7176.1	7847.6	4.46
San Gregorio	37 18 49.87	122 22 54.45	196 15 52	Wetner 2	16 16 13	3112.8	3404.1	1.93
			236 35 06	Hamilton	56 36 52	5172.0	5656.0	3.21
Jack	37 15 21.76	122 23 48.07	204 48 55	Pescadero	24 49 16	2056.4	2248.8	1.28
			228 30 27	Peak	48 32 23	6315.2	6906.1	3.92
Frijoles	37 13 17.88	122 23 33.50	311 05 47	Young	131 06 41	2941.4	3216.6	1.83
			351 10 16	Bolsa	171 10 28	3144.1	3438.3	1.95
Hill Top, single tree	37 08 48.96	122 16 36.74	90 40 44	Middle Point	270 38 20	5900.8	6453.0	3.67
			121 15 19	Ranch	301 12 29	8143.9	8906.0	5.06
San Francisco, Cal.								
TELEGRAPH HILL	37 48 00.07	122 23 19.39						
Union street station	37 47 53.17	122 23 32.92	237 16 05	Telegraph Hill	57 16 13	393.5	430.3	0.24
Washington Square, engine-house.	37 48 00.69	122 23 32.92	273 18 57	Telegraph Hill	93 19 05	331.6	362.6	0.21
			0 00 00	Union street station	180 00 00	231.9	253.6	0.14
Washington Square, observatory.	37 47 55.34	122 23 32.92	0 00 00	Union street station	180 00 00	67.0	73.3	0.04
			180 00 00	Engine-house	0 00 00	165.0	180.4	0.10
Suisun Bay, Cal.								
ARMY POINT	38 02 54.08	122 06 49.02						
ISLAND	38 01 41.52	122 05 27.50	138 23 09	Army Point	318 22 19	2992.4	3272.4	1.86
Edith	38 03 05.09	122 03 12.80	86 20 06	Army Point	266 17 53	5281.9	5776.1	3.28
			51 53 56	Island	231 52 33	4174.1	4564.7	2.59
Goodyear	38 06 13.60	122 05 14.18	20 36 07	Army Point	200 35 09	6570.9	7185.7	4.08
			333 00 56	Edith	153 02 11	6521.1	7131.3	4.05
Seal Bluff	38 03 10.47	122 01 21.34	134 52 34	Goodyear	314 50 10	8004.1	8753.1	4.97
			86 30 47	Edith	266 29 38	2722.2	2976.9	1.69
Buckler	38 05 42.65	122 00 14.10	19 15 38	Seal Bluff	199 14 57	4969.5	5434.5	3.09
			97 27 37	Goodyear	277 24 32	7372.5	8062.3	4.58
Freeman	38 04 31.54	121 58 26.11	59 40 54	Seal Bluff	239 39 06	4948.4	5411.4	3.07
			129 48 47	Buckler	309 47 40	3424.9	3745.4	2.13
Hewston	38 08 11.18	121 59 57.28	5 06 50	Buckler	185 06 40	4597.2	5027.4	2.86
			64 52 11	Goodyear	244 48 55	8527.0	9324.9	5.30
Garnett	38 05 09.58	122 01 20.39	109 07 48	Goodyear	289 05 24	6028.0	6592.0	3.75
			199 52 27	Hewston	19 53 18	5953.2	6510.2	3.70
Green	38 04 05.50	122 01 45.99	48 39 23	Edith	228 38 29	2818.8	3082.5	1.75
			127 55 09	Goodyear	307 53 01	6428.8	7030.3	3.99
Stephenson	38 03 08.84	121 58 31.98	90 42 43	Seal Bluff	270 40 59	4128.8	4515.1	2.57
			183 12 41	Freeman	3 12 45	2553.3	2792.2	1.59
Sun	38 05 35.68	122 03 54.46	347 39 41	Edith	167 40 07	4752.5	5197.2	2.95
			40 30 33	Army Point	220 28 45	6551.4	7164.4	4.07
Moon	38 05 15.16	122 04 21.32	337 23 06	Edith	157 23 48	4344.0	4750.5	2.70
			39 37 29	Army Point	219 35 58	5645.9	6174.2	3.51
Preston Point	38 04 07.25	122 01 46.63	73 00 38	Army Point	252 57 32	7708.3	8429.6	4.79
			127 37 26	Goodyear	307 35 18	6383.4	6980.7	3.97
Bull	38 02 00.19	122 03 38.44	77 47 43	Island	257 46 36	2721.0	2975.6	1.69
			109 41 25	Army Point	289 39 28	4934.6	5396.3	3.07

GEOGRAPHICAL POSITIONS—Continued.

Section X.—Suisun Bay, Cal.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Bay	38 03 56.05	122 06 17.65	289 12 23	Edith	109 14 17	4771.9	5218.4	2.96
			21 48 54	Army Point	201 48 35	2057.7	2250.2	1.28
Mart	38 01 59.63	122 04 40.26	118 08 36	Army Point	298 07 17	3559.9	3893.0	2.21
			226 34 20	Edith	46 35 14	2935.7	3210.4	1.82
Mass	38 03 25.22	122 01 42.90	74 11 46	Edith	254 10 51	2277.7	2490.8	1.42
			135 15 13	Goodyear	315 13 03	7311.3	7995.4	4.54
King	38 05 16.40	122 01 06.27	43 53 23	Island	223 50 42	9188.8	10048.6	5.71
			62 19 09	Army Point	242 15 38	9435.8	10318.7	5.86
Delta	38 07 31.97	122 03 23.77	339 41 03	Seal Bluff	159 42 19	8596.0	9400.4	5.34
			48 04 08	Goodyear	228 03 00	3615.3	3953.6	2.25
Martinez	38 01 00.61	122 07 42.73	200 31 11	Army Point	20 31 44	3735.1	4084.6	2.32
			249 03 41	Island	69 05 04	3530.6	3861.0	2.19
Arsenal, flag-staff	38 02 37.97	122 06 54.75	195 41 58	Army Point	15 42 02	515.8	564.0	0.32
			309 16 51	Island	129 17 45	2748.5	3005.7	1.71
Marked tree	38 01 48.24	122 05 19.14	132 48 47	Army Point	312 47 52	2986.9	3266.3	1.86
			180 50 48	Goodyear	0 50 51	8181.6	8947.1	5.08
Simmons	38 05 07.86	121 57 43.35	150 00 57	Hewston	329 59 34	6525.3	7135.9	4.05
			90 35 33	Garnett	270 33 19	5288.8	5783.6	3.29
Hill	38 01 46.39	121 59 05.34	197 49 41	Simmons	17 50 32	6524.8	7135.3	4.05
			152 17 18	Garnett	332 15 55	7076.5	7738.6	4.40
Mallard	38 02 20.43	121 55 01.34	142 35 46	Simmons	322 34 06	6499.2	7107.4	4.04
			80 01 10	Hill	259 58 40	6041.3	6606.6	3.75
McDuff	38 05 25.01	121 53 42.75	84 52 00	Simmons	264 49 32	5886.2	6437.0	3.66
			18 36 31	Mallard	198 35 43	6004.3	6566.1	3.73
New York	38 02 15.00	121 52 14.32	159 48 21	McDuff	339 47 26	6242.1	6826.2	3.88
			92 22 11	Mallard	272 20 28	4075.8	4457.1	2.53
Collinsville	38 05 24.27	121 49 59.39	90 15 36	McDuff	270 13 18	5442.2	5951.4	3.38
			29 24 58	New York	209 23 35	6698.1	7324.9	4.16
Coon	38 08 25.75	122 02 24.86	277 06 55	Hewston	97 08 26	3621.5	3960.3	2.25
			345 26 18	Garnett	165 26 58	6248.3	6833.0	3.88
Brant	38 08 49.97	121 59 02.68	26 17 06	Garnett	206 15 41	7577.3	8286.3	4.71
			344 14 12	Simmons	164 15 01	7114.8	7780.5	4.42
Upper	38 06 36.27	121 58 14.51	59 28 08	Garnett	239 26 13	5258.3	5750.3	3.27
			139 27 50	Hewston	319 26 46	3850.2	4210.4	2.39
Otter	38 04 18.82	121 57 05.89	148 52 45	Simmons	328 52 22	1766.1	1931.4	1.10
			31 47 40	Hill	211 46 26	5528.1	6045.4	3.44
Goose	38 08 33.20	121 56 37.18	82 04 51	Hewston	262 02 47	4919.2	5379.5	3.06
			47 43 17	Garnett	227 40 22	9327.0	10199.8	5.80
Knox	38 03 10.08	121 55 03.38	132 58 39	Simmons	312 57 00	5327.8	5826.3	3.31
			66 23 55	Hill	246 21 26	6438.6	7041.1	4.00
Cupola	38 06 56.52	121 55 23.83	45 25 41	Simmons	225 24 15	4772.2	5218.7	2.97
			109 05 19	Hewston	289 02 30	7045.7	7704.9	4.38
Honker	38 04 44.33	121 54 45.99	99 32 36	Simmons	279 30 47	4382.5	4792.5	2.72
			49 04 29	Hill	229 01 49	8370.2	9153.4	5.20
Tripod	38 09 25.48	121 54 18.21	32 11 24	Simmons	212 09 17	9383.1	10261.1	5.83
			74 31 05	Hewston	254 27 36	8567.1	9368.7	5.32
Black house, chimney	38 03 25.23	121 53 27.03	116 53 03	Simmons	296 50 25	7002.6	7657.8	4.35
			69 45 14	Hill	249 41 46	8792.9	9615.7	5.46
Barrel	38 02 53.93	121 52 51.91	322 38 17	New York	142 38 40	1510.3	1651.6	0.94
			71 53 10	Mallard	251 51 50	3320.3	3630.9	2.06
Bush	38 03 25.95	121 50 23.17	51 05 49	New York	231 04 40	3482.4	3808.2	2.16
			189 01 24	Collinsville	9 01 39	3693.5	4039.1	2.29
Depot, flag-staff	38 04 19.21	121 49 59.86	40 34 21	New York	220 32 58	5040.6	5512.3	3.13
			110 29 56	McDuff	290 27 39	5798.1	6340.7	3.60
White house, gable	38 03 30.52	121 48 21.84	67 41 10	New York	247 38 47	6127.1	6700.4	3.81
			145 52 30	Collinsville	325 51 30	4236.8	4633.2	2.63
Antioch, brick tower	38 00 52.40	121 47 35.66	110 33 55	New York	290 31 03	7256.9	7935.9	4.51
			157 19 28	Collinsville	337 17 59	9084.5	9934.5	5.64

GEOGRAPHICAL POSITIONS—Continued.

Section XI.—Straits of Juan de Fuca, W. T., and Vancouver Island, B. C.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Ross	48 08 31.21	122 46 34.55	...	...	...	...	...	...
PARTRIDGE	48 12 52.34	122 45 06.74	12 41 03	Ross	192 39 58	8266.0	9039.4	5.14
Admiralty Head light	48 09 15.79	122 40 09.47	80 13 32	Ross	260 08 45	8076.6	8832.3	5.02
			137 28 48	Partridge	317 25 06	9078.4	9927.9	5.64
Mast	48 11 58.26	122 43 35.70	30 02 15	Ross	210 00 02	7385.1	8076.1	4.59
			131 38 09	Partridge	311 37 01	2514.2	2749.5	1.56
Middle	48 08 09.36	122 49 45.39	213 20 20	Partridge	33 23 48	10464.6	11443.7	6.50
			260 16 10	Ross	80 18 32	4001.9	4376.4	2.49
Protection	48 07 55.30	122 55 14.93	233 48 01	Partridge	53 55 34	15555.8	17011.3	9.67
			264 03 36	Ross	84 10 03	10813.7	11825.5	6.72
Smith's Island light	48 19 04.01	122 50 11.06	346 06 06	Ross	167 08 48	20048.2	21924.1	12.46
			52 48 58	Dungeness	232 36 57	25052.7	27396.9	15.57
San Juan	48 27 33.98	123 01 42.77	317 50 04	Smith's Island light	137 58 41	21225.6	23211.7	13.19
			74 45 26	Discovery	254 36 54	14566.4	15929.4	9.05
Port Angelos light	48 08 20.88	123 23 42.35	257 38 39	Dungeness	77 51 37	22092.4	24159.6	13.73
			202 21 20	Discovery	22 29 15	34363.7	37579.1	21.35
Mount Tolmie	48 27 21.40	123 19 01.98	235 55 24	Bellevue	56 02 43	14517.7	15876.1	9.02
			295 17 54	Discovery	115 22 20	8082.3	8838.5	5.02
Gonzales	48 24 46.43	123 19 00.85	179 43 19	Mount Tolmie	359 43 18	4786.2	5234.1	2.97
			259 38 05	Discovery	79 42 30	7404.8	8097.6	4.60
Soughies	48 25 55.74	123 22 38.76	239 16 08	Mount Tolmie	59 18 50	5180.9	5665.7	3.22
			295 31 01	Gonzales	115 33 44	4964.6	5429.1	3.08
Astronomical station at Victoria.	48 25 23.68	123 22 05.88	145 41 15	Soughies	325 40 51	1198.8	1310.9	0.74
			226 05 16	Mount Tolmie	46 07 33	5244.1	5734.8	3.26
Puget Sound, Vashon Island, and Anderson Island, W. T.								
BEALS	47 27 54.65	122 25 30.93	...	...	...	...	...	...
PULLY	47 27 00.31	122 22 21.48	112 56 40	Beals	292 54 20	4307.8	4710.8	2.68
HYER	47 25 19.49	122 25 17.34	176 36 00	Beals	356 35 50	4799.8	5248.9	2.98
			229 47 00	Pully	49 49 09	4823.6	5274.9	3.00
Greenbank	47 24 55.99	122 20 22.39	96 43 26	Hyer	276 39 49	6224.0	6806.4	3.87
			146 59 14	Pully	326 57 46	4578.6	5007.0	2.85
Robinson	47 23 16.13	122 21 56.07	132 05 50	Hyer	312 03 22	5684.4	6216.3	3.53
			175 36 13	Pully	355 35 54	6943.1	7592.8	4.31
Lunch	47 21 48.57	122 18 59.46	129 27 32	Hyer	309 22 54	10256.7	11216.4	6.37
			126 08 36	Robinson	306 06 26	4586.2	5015.3	2.85
Robinson II	47 23 07.25	122 22 04.71	212 33 46	Greenbank	32 35 01	3984.6	4357.4	2.48
			301 59 59	Lunch	122 02 15	4582.7	5011.5	2.85
Dash	47 19 07.66	122 25 15.67	209 44 23	Greenbank	29 47 59	12391.6	13551.0	7.70
			208 25 18	Robinson II	28 27 39	8413.9	9201.2	5.23
Piner	47 20 34.30	122 26 47.80	256 49 01	Lunch	76 54 46	10091.6	11035.8	6.27
			231 28 41	Robinson	51 32 10	7588.2	8298.3	4.72
Portage	47 24 25.46	122 25 47.22	222 00 57	Pully	42 03 28	6438.2	7040.7	4.00
			200 34 25	Hyer	20 34 47	1782.0	1948.8	1.11
Cedar Hill	47 26 20.58	122 25 53.57	254 32 30	Pully	74 35 06	4609.0	5040.2	2.86
			318 49 25	Robinson	138 52 20	7564.5	8272.3	4.70
Thompson	47 23 10.33	122 19 06.53	92 54 06	Robinson	272 52 01	3559.9	3893.0	2.21
			88 33 48	Robinson II	268 31 37	3737.8	4087.5	2.32
Soldier	47 23 45.31	122 19 06.73	72 32 43	Robinson II	252 30 32	3912.3	4278.4	2.43
			58 40 18	Piner	238 34 38	11328.7	12388.7	7.04
Neill	47 19 48.68	122 29 06.78	244 12 26	Piner	64 14 08	3239.6	3542.7	2.01
			284 36 17	Dash	104 39 07	5014.8	5484.0	3.12
North Defiance	47 18 56.35	122 31 28.15	242 46 13	Piner	62 49 39	6617.2	7236.4	4.11
			241 25 13	Neill	61 26 57	3379.4	3695.6	2.10
Peeyallup	47 18 21.90	122 30 33.71	214 15 10	Neill	34 16 13	3242.1	3545.5	2.01
			132 56 11	North Defiance	312 55 31	1561.5	1707.6	0.97
Dalco	47 20 38.21	122 31 09.13	349 58 33	Peeyallup	169 58 59	4274.2	4674.1	2.66
			7 14 08	North Defiance	187 13 54	3170.7	3467.4	1.97

GEOGRAPHICAL POSITIONS—Continued.

Section XI.—Puget Sound, Vashon Island, and Anderson Island, W. T.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Cutter	47 20 49.03	122 32 53.10	278 41 25	Dalco	98 42 42	2207.4	2414.0	1.37
			332 51 16	North Defiance	152 52 19	3909.8	4275.6	2.43
Pinnace	47 18 00.81	122 33 06.15	183 01 03	Cutter	3 01 13	5201.5	5688.2	3.23
			206 48 16	Dalco	26 49 42	5446.0	5955.6	3.38
Gig	47 19 33.61	122 33 51.54	239 39 03	Dalco	59 41 03	3949.8	4319.4	2.45
			341 35 47	Pinnace	161 36 21	3020.0	3302.6	1.88
Maple	47 18 40.85	122 32 06.43	45 24 58	Pinnace	225 24 14	1761.2	1926.0	1.09
			126 26 42	Gig	306 25 25	2743.0	2999.7	1.70
Narrows	47 17 11.96	122 31 14.04	122 39 11	Pinnace	302 37 48	2796.7	3058.4	1.74
			158 09 41	Maple	338 09 02	2957.2	3233.9	1.84
Evans	47 17 04.10	122 32 23.90	187 00 13	Maple	7 00 26	3010.2	3291.8	1.87
			260 35 53	Narrows	80 36 45	1487.8	1627.0	0.92
Lake	47 15 47.53	122 32 11.40	173 39 39	Evans	353 39 30	2379.0	2601.6	1.48
			204 48 21	Narrows	24 49 03	2872.5	3141.2	1.78
Camp	47 15 56.18	122 33 22.07	228 58 05	Narrows	48 59 39	3565.7	3899.3	2.22
			280 11 13	Lake	100 12 05	1509.1	1650.3	0.94
Day	47 14 35.17	122 33 16.97	177 32 51	Camp	357 32 47	2503.7	2737.9	1.56
			211 39 57	Lake	31 40 45	2625.3	2871.0	1.63
Fosdick	47 15 17.44	122 34 20.58	251 05 55	Lake	71 07 30	2870.0	3138.5	1.78
			314 17 46	Day	134 18 33	1868.9	2043.7	1.16
East Fox	47 13 38.35	122 34 54.87	193 15 26	Fosdick	13 15 51	3143.6	3437.7	1.95
			229 33 13	Day	49 34 25	2705.1	2958.2	1.68
Bolton	47 12 35.80	122 34 14.80	156 25 34	East Fox	336 25 05	2107.5	2304.7	1.31
			198 15 23	Day	18 16 05	3881.6	4244.8	2.41
Gibson	47 13 08.51	122 35 34.40	227 11 33	Day	47 13 14	3938.9	4307.4	2.45
			301 05 30	Bolton	121 06 29	1955.7	2138.7	1.22
Gove	47 09 59.49	122 37 23.54	201 28 21	Gibson	21 29 41	6272.3	6859.2	3.90
			219 26 24	Bolton	39 28 43	6251.1	6836.0	3.88
Upper	47 10 05.04	122 36 17.46	209 00 05	Bolton	29 01 35	5323.3	5821.4	3.31
			189 05 07	Gibson	9 05 39	5737.5	6274.4	3.56
Hyde	47 11 55.27	122 38 10.30	344 35 55	Gove	164 36 29	3708.1	4055.1	2.30
			325 04 46	Upper	145 06 08	4150.8	4539.2	2.58
Hornet	47 10 21.77	122 39 55.15	282 08 41	Gove	102 10 32	3265.8	3571.3	2.03
			276 24 39	Upper	96 27 19	4612.8	5944.5	2.87
Ketron	47 09 02.50	122 37 51.25	133 11 02	Hornet	313 09 31	3577.9	3912.6	2.22
			175 42 05	Hyde	355 41 51	5350.1	5850.7	3.32
Shower	47 07 45.89	122 38 43.19	215 31 51	Upper	35 33 38	5280.3	5774.3	3.28
			204 49 18	Ketron	24 49 56	2606.2	2850.1	1.62
Oro	47 08 32.06	122 40 05.02	251 32 30	Ketron	71 34 08	2970.5	3248.4	1.85
			309 34 36	Shower	129 35 36	2237.1	2446.5	1.39
Pickle	47 08 59.24	122 39 56.54	325 41 16	Shower	145 42 10	2741.9	2998.5	1.70
			202 21 15	Hyde	22 22 40	5877.6	6427.6	3.65
Run	47 08 16.31	122 37 23.65	140 32 10	Hornet	320 30 19	5019.0	5488.6	3.12
			202 32 38	Upper	22 33 26	3635.0	3975.2	2.26
Rose	47 08 49.76	122 37 42.90	217 44 17	Upper	37 45 20	2939.6	3214.7	1.83
			338 32 57	Run	158 33 11	1109.6	1213.4	0.69
Balch	47 11 27.47	122 40 12.83	297 10 00	Upper	117 12 53	5570.7	6092.0	3.46
			349 36 19	Hornet	169 36 32	2062.5	2255.4	1.28
Wirts	47 12 20.20	122 38 01.47	264 12 34	Bolton	84 15 20	4793.8	5242.4	2.98
			332 18 30	Upper	152 19 46	4712.9	5153.9	2.93
Goldsborough	47 13 25.92	122 36 31.33	357 18 18	Upper	177 18 28	6209.8	6790.8	3.86
			43 04 15	Wirts	223 03 09	2777.6	3037.5	1.73
Yoman	47 10 51.02	122 40 28.55	292 11 50	Gove	112 14 06	4207.9	4601.6	2.61
			285 00 33	Upper	105 03 37	5474.0	5986.2	3.40
Steilacoom, Presbyter'n church spire.	47 10 20.99	122 35 10.73	90 15 31	Hornet	270 12 01	5988.5	6548.8	3.72
			76 39 34	Gove	256 37 57	2874.2	3143.1	1.79
Steilacoom, Methodist church spire.	47 10 19.96	122 35 25.85	90 35 42	Hornet	270 32 24	5670.3	6200.8	3.52
			75 42 50	Gove	255 41 24	2557.3	2796.6	1.59
Tchelacoom	47 11 01.44	122 34 35.08	119 15 39	Wirts	299 13 08	4978.2	5444.0	3.09
			151 16 26	Goldsborough	331 15 01	5087.8	5563.8	3.16

GEOGRAPHICAL POSITIONS—Continued.

Section XI.—Puget Sound, Vashon Island, and Anderson Island, W. T.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Shaaf	47 12 52.79	122 38 26.77	247 08 42	Goldsborough	67 10 07	2635.0	2881.6	1.64
			332 07 35	Wirts	152 07 54	1138.5	1245.0	0.71
Grass	47 14 18.49	122 35 13.68	211 31 04	Fosdick	31 31 43	2135.5	2335.3	1.33
			258 08 03	Day	78 09 29	2507.7	2742.3	1.56
Marked tree 23	47 16 30.24	122 32 46.98	10 03 57	Day	199 03 35	3608.7	3946.3	2.24
			236 34 40	Narrows	56 35 48	2339.4	2558.3	1.45
Marked tree 24	47 14 51.00	122 32 36.91	110 32 42	Fosdick	290 31 26	2327.5	2545.3	1.45
			151 45 25	Camp	334 44 52	2225.3	2433.5	1.38
Marked tree 25	47 14 00.00	122 33 19.86	71 30 56	East Fox	251 29 46	2107.1	2304.3	1.31
			151 54 31	Fosdick	331 53 46	2710.8	2964.5	1.68
Marked tree 26	47 11 37.71	122 39 09.39	341 02 48	Ketron	161 03 45	5067.4	5541.6	3.15
			323 40 47	Gove	143 42 05	3763.4	4115.5	2.34
Marked tree 27	47 08 48.28	122 36 48.51	92 17 17	Rose	272 16 37	1146.8	1254.1	0.71
			195 25 12	Upper	15 25 35	2458.6	2688.6	1.53
Marked tree 28	47 09 24.59	122 37 16.70	224 57 33	Upper	44 58 16	1765.3	1930.5	1.10
			3 58 18	Run	183 58 13	2113.2	2310.9	1.31
Marked tree 29	47 07 57.29	122 38 21.02	156 02 50	Hornet	336 01 41	4882.1	5338.9	3.03
			160 04 07	Balch	340 02 45	6903.8	7549.8	4.29
Defiance	47 19 00.83	122 32 21.16	118 05 08	Gig	298 04 02	2150.8	2352.1	1.34
			206 41 17	Dalco	26 42 10	3365.7	3680.6	2.09
Reading	47 22 11.76	122 32 01.72	339 05 16	Dalco	159 05 55	3092.3	3381.6	1.92
			22 52 57	Cutter	202 52 19	2772.9	3032.4	1.72
Passage	47 21 55.58	122 30 51.63	51 07 58	Cutter	231 06 29	3274.1	3580.5	2.03
			108 46 28	Reading	288 45 36	1553.0	1698.3	0.96
Ridge	47 23 03.41	122 30 45.42	3 33 29	Passage	183 33 24	2098.6	2295.0	1.30
			45 06 22	Reading	225 05 26	2259.4	2470.8	1.40
Richmond	47 22 34.01	122 31 50.00	236 09 58	Ridge	56 10 46	1630.5	1783.0	1.01
			314 06 02	Passage	134 06 45	1705.3	1864.9	1.06
Woodpecker	47 24 02.50	122 32 36.09	308 09 58	Ridge	128 11 20	2952.1	3228.3	1.83
			340 30 50	Richmond	160 31 24	2898.3	3169.5	1.80
Sandford	47 23 45.76	122 31 08.84	21 17 29	Richmond	201 16 59	2377.7	2600.2	1.48
			353 56 32	Passage	173 56 45	3421.4	3741.5	2.13
Thistle	47 25 02.95	122 30 21.77	22 29 29	Sandford	202 28 54	2579.8	2821.2	1.60
			56 28 15	Woodpecker	236 26 36	3378.2	3694.3	2.10
Prospect	47 25 44.23	122 31 25.68	313 35 02	Thistle	133 35 49	1849.3	2022.4	1.15
			354 29 09	Sandford	174 29 21	3675.7	4019.6	2.28
Teka	47 25 09.02	122 31 57.87	275 18 23	Thistle	95 19 33	2022.7	2212.0	1.26
			338 12 19	Sandford	158 12 55	2768.9	3027.9	1.72
Andrew	47 26 22.61	122 30 19.38	1 10 04	Thistle	181 10 02	2460.3	2690.5	1.53
			42 15 21	Teka	222 14 08	3069.7	3357.0	1.91
Marked tree 12	47 23 13.84	122 32 31.44	240 21 06	Sandford	60 22 07	1992.8	2179.3	1.24
			278 14 11	Ridge	98 15 29	2246.4	2456.6	1.40
Marked tree 13	47 24 41.99	122 32 11.18	254 13 33	Thistle	74 14 54	2382.7	2605.7	1.48
			323 01 36	Sandford	143 02 22	2173.2	2376.5	1.35
Marked tree 19	47 24 24.35	122 30 45.25	132 11 14	Teka	312 10 21	2054.2	2246.4	1.28
			188 26 29	Andrew	8 26 48	3691.7	4037.2	2.29
Marked tree 20	47 22 25.89	122 30 27.78	98 17 36	Richmond	278 16 35	1742.6	1905.6	1.08
			137 57 27	Woodpecker	317 55 53	4017.2	4393.1	2.50
Marked tree 22	47 21 32.29	122 32 37.78	311 54 18	Dalco	131 55 23	2500.0	2733.9	1.55
			343 06 29	North Defiance	163 07 20	5032.4	5503.3	3.13
South Vashon	47 19 57.75	122 30 17.32	6 37 53	Peeyallup	186 37 41	2979.7	3258.5	1.85
			38 06 39	North Defiance	218 05 47	2409.7	2635.2	1.50
Toby	47 18 18.31	122 26 09.20	169 04 45	Piner	349 04 17	4276.8	4676.9	2.66
			216 24 43	Dash	36 25 22	1893.6	2070.7	1.18
Harman	47 16 19.09	122 26 48.85	180 09 33	Piner	0 09 34	7880.8	8618.2	4.90
			192 44 43	Toby	12 45 12	3774.6	4127.8	2.35
Harris	47 17 55.34	122 25 58.83	19 28 41	Harman	199 28 04	3152.2	3447.1	1.96
			105 16 17	North Defiance	285 12 15	7168.3	7839.1	4.45
Pebble Bluff	47 17 00.09	122 23 47.32	71 39 32	Harman	251 37 19	4019.2	4395.3	2.50
			121 42 25	Harris	301 40 48	3247.2	3551.1	2.02

GEOGRAPHICAL POSITIONS—Continued.

Section XI.—Puget Sound, Vashon Island, and Anderson Island, W. T.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
North	47 16 14.21	122 23 27.44	92 03 43	Harman	272 01 15	4235.5	4631.8	2.63
			134 29 15	Harris	314 27 24	4457.6	4874.7	2.77
Middle	47 15 41.81	122 24 01.10	108 05 59	Harman	288 03 56	3709.0	4056.0	2.30
			149 02 52	Harris	329 01 26	4808.4	5258.3	2.99
South	47 15 10.19	122 24 05.77	121 50 39	Harman	301 48 39	4034.4	4411.9	2.51
			155 01 51	Harris	335 00 28	5625.8	6152.2	3.50
George	47 16 46.98	122 28 11.04	168 13 10	Neill	348 12 29	5731.3	6267.6	3.56
			230 16 48	Dash	40 18 57	5695.7	6228.6	3.54

ERRATA.

Page 246. ABAGADUSSET, line 11, insert comma after word.
Page 247. BEDABEDEC, strike out [9] after BEDABEDEC, and insert [9] after Champlain.
Page 252. Line 3, after *Kwapskitchcpok*, change comma to period.
Page 252. MEDOMAC, line 2, change hyphen in *matta-not* to comma.
Page 252. MEGUNTICOOK, line 3, change hyphen in *cook-place* to comma.
Page 252. *Note* 5, for Caryon read Carayon.
Page 253. MONSEAG, line 2, change *moris*, at to *mons*, as; line 3, after Loon Bay, commence another paragraph with MOOSEBECK.
Page 257. PISCATAQUA, line 7, strike out [1] after two, and affix it to names, line 10; line 11, for *pesketegove* read *pesketegooe*.
Page 258. SASANOA, line 5, put by-river of some note in quotation-marks.
Page 258. *Note* 1, line 2, strike out quotation-marks after Pople, and insert them after plans, line 3; strike out quotation-marks before Strachey's, line 3, and insert them before for, line 4.

			56 04 39	Work	236 03 54	1544.4	1688.9	0.96
Root	47 21 42.26	122 28 47.79	275 06 32	Mire	95 07 13	1167.9	1277.1	0.73
			319 54 39	Phalon	139 55 11	1427.8	1561.4	0.89
Shell	47 22 23.13	122 27 19.38	26 50 50	Mire	206 50 26	1531.1	1674.4	0.95
			55 46 30	Root	235 45 25	2243.2	2453.1	1.39
Goose	47 22 55.82	122 28 21.97	307 33 20	Shell	127 34 06	1655.9	1810.9	1.03
			13 24 57	Root	193 24 38	2335.1	2553.6	1.45
Trunk	47 22 59.48	122 26 40.82	35 46 45	Shell	215 46 17	1383.7	1513.1	0.86
			86 57 21	Goose	266 56 07	2124.3	2323.1	1.32
Weir	47 22 54.72	122 26 01.75	59 05 00	Shell	239 04 03	1898.2	2075.8	1.18
			100 10 04	Trunk	280 10 35	832.4	910.3	0.52
Rander	47 23 02.30	122 26 31.82	290 22 08	Weir	110 22 30	672.7	735.7	0.42
			39 31 05	Shell	219 30 30	1568.0	1714.7	0.97
Marked tree A	47 23 13.30	122 27 19.35	0 01 33	Shell	180 01 33	1549.4	1694.4	0.96
			67 39 12	Goose	247 38 26	1419.8	1552.6	0.88
Scarlet	47 23 37.25	122 25 46.20	40 30 08	Shell	220 28 59	3009.7	3291.3	1.87
			41 33 51	Rander	221 33 17	1442.1	1577.0	0.90
Offal	47 23 20.49	122 26 15.57	229 57 23	Scarlet	49 57 45	804.4	879.7	0.50
			339 59 04	Weir	159 59 14	846.8	926.0	0.53
Tuttle	47 24 07.23	122 26 26.04	317 56 20	Scarlet	137 56 49	1247.0	1363.7	0.77
			351 20 54	Offal	171 21 02	1460.0	1596.6	0.91

GEOGRAPHICAL POSITIONS—Continued.

Section XI.—Puget Sound, Vashon Island, and Anderson Island, W. T.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
North	47 16 14.21	122 23 27.44	92 03 43	Harman	272 01 15	4235.5	4631.8	2.63
			134 29 15	Harris	314 27 24	4457.6	4874.7	2.77
Middle	47 15 41.81	122 24 01.10	108 05 59	Harman	288 03 56	3709.0	4056.0	2.30
			149 02 52	Harris	329 01 26	4808.4	5258.3	2.99
South	47 15 10.19	122 24 05.77	121 50 39	Harman	301 48 39	4034.4	4411.9	2.51
			155 01 51	Harris	335 00 28	5625.8	6152.2	3.50
George	47 16 46.98	122 28 11.04	168 13 10	Neill	348 12 29	5731.3	6267.6	3.56
			220 16 48	Dash	40 18 57	5695.7	6228.6	3.54
Landslide	47 17 29.34	122 29 13.17	181 47 09	Neill	1 47 14	4304.8	4707.5	2.67
			238 38 51	Dash	58 41 46	5839.6	6386.0	3.63
Marked tree 7	47 19 26.89	122 22 39.50	111 47 49	Piner	291 44 46	5612.6	6137.7	3.49
			186 07 11	Robinson II	6 07 37	6843.8	7484.2	4.25
Nemo	47 20 51.44	122 18 57.85	86 58 35	Piner	266 52 49	9877.0	10801.2	6.14
			136 57 06	Robinson II	316 54 49	5740.6	6277.8	3.57
Breaker	47 20 24.31	122 19 49.47	92 03 24	Piner	271 58 16	8785.5	9607.5	5.46
			150 35 48	Robinson II	330 34 08	5776.6	6317.1	3.59
Honeysuckle	47 19 57.49	122 21 53.70	100 27 52	Piner	280 24 16	6276.9	6864.2	3.90
			177 44 41	Robinson II	357 44 33	5864.4	6413.1	3.64
Flicker	47 19 11.88	122 24 14.48	200 31 33	Robinson II	20 33 08	7761.7	8488.0	4.82
			84 13 33	Dash	264 12 48	1291.4	1412.2	0.80
Master	47 20 00.04	122 28 59.05	311 21 18	Toby	131 23 23	4752.5	5197.2	2.95
			289 00 16	Dash	109 03 00	4960.9	5425.1	3.08
Zephyr	47 21 16.38	122 26 25.15	339 51 02	Dash	159 51 24	4233.8	4630.0	2.63
			263 53 14	Lunch	83 58 42	9403.9	10283.9	5.84
Middle Maury	47 22 13.77	122 24 49.52	318 44 27	Honeysuckle	138 46 36	5596.7	6120.3	3.48
			276 00 48	Lunch	96 05 06	7384.7	8075.6	4.59
Lath	47 22 45.25	122 23 38.99	336 53 31	Honeysuckle	156 54 48	5631.7	6158.7	3.50
			286 35 32	Lunch	106 38 58	6119.2	6691.8	3.80
Marked tree 4, (1867)	47 23 57.49	122 24 03.33	200 41 32	Pully	20 42 47	6034.8	6599.4	3.75
			148 31 49	Hyer	328 30 55	2969.3	3247.2	1.85
Valley	47 26 32.78	122 20 55.34	67 37 23	Hyer	247 34 10	5937.7	6493.3	3.69
			11 50 45	Robinson	191 50 00	6204.3	6784.8	3.86
Quarter	47 20 52.29	122 27 57.00	334 32 09	Toby	154 33 28	5265.9	5758.7	3.27
			38 55 00	Master	218 54 15	2073.7	2267.7	1.29
Work	47 21 10.97	122 28 53.41	295 58 12	Quarter	115 58 54	1316.9	1440.1	0.82
			3 05 41	Master	183 05 37	2193.5	2398.7	1.36
Phalon	47 21 06.88	122 28 03.97	29 15 27	Master	209 14 46	2365.8	2587.1	1.47
			96 56 34	Work	276 55 58	1045.1	1142.9	0.65
Mire	47 21 38.89	122 27 52.34	13 52 24	Phalon	193 52 15	1017.9	1113.1	0.63
			56 04 39	Work	236 03 54	1544.4	1688.9	0.96
Root	47 21 42.26	122 28 47.79	275 06 32	Mire	95 07 13	1167.9	1277.1	0.73
			319 54 39	Phalon	139 55 11	1427.8	1561.4	0.89
Shell	47 22 23.13	122 27 19.38	26 50 50	Mire	206 50 26	1531.1	1674.4	0.95
			55 46 30	Root	235 45 25	2243.2	2453.1	1.39
Goose	47 22 55.82	122 28 21.97	307 33 20	Shell	127 34 06	1655.9	1810.9	1.03
			13 24 57	Root	193 24 38	2335.1	2553.6	1.45
Trunk	47 22 59.48	122 26 40.82	35 46 45	Shell	215 46 17	1383.7	1513.1	0.86
			86 57 21	Goose	266 56 07	2124.3	2323.1	1.32
Weir	47 22 54.72	122 26 01.75	59 05 00	Shell	239 04 03	1898.2	2075.8	1.18
			100 10 04	Trunk	280 10 35	832.4	910.3	0.52
Rander	47 23 02.30	122 26 31.82	290 22 08	Weir	110 22 30	672.7	735.7	0.42
			39 31 05	Shell	219 30 30	1568.0	1714.7	0.97
Marked tree A	47 23 13.30	122 27 19.35	0 01 33	Shell	180 01 33	1549.4	1694.4	0.96
			67 39 12	Goose	247 38 26	1419.8	1552.6	0.88
Scarlet	47 23 37.25	122 25 46.20	40 30 08	Shell	220 28 59	3009.7	3291.3	1.87
			41 33 51	Rander	221 33 17	1442.1	1577.0	0.90
Offal	47 23 20.49	122 26 15.57	229 57 23	Scarlet	49 57 45	804.4	879.7	0.50
			339 59 04	Weir	159 59 14	846.8	926.0	0.53
Tuttle	47 24 07.23	122 26 26.04	317 56 20	Scarlet	137 56 49	1247.0	1363.7	0.77
			351 20 54	Offal	171 21 02	1460.0	1596.6	0.91

GEOGRAPHICAL POSITIONS—Continued.

Section XI.—Puget Sound, Vashon Island, and Anderson Island, W. T.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Dist.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Meters.*	*Yards.*	*Miles.*
Turf	47 23 41.16	122 27 25.07	236 56 28	Tuttle	56 57 11	1476.4	1614.5	0.92
			273 19 11	Scarlet	93 20 24	2076.5	2270.8	1.29
Gulf of Georgia, W. T.								
EAST ROBERTS	48 58 24.86	123 01 06.56	....	....	....	....	....	....
WEST ROBERTS	48 58 15.88	123 04 30.68	....	....	....	....	....	....
Rock	48 53 58.77	123 19 33.55	249 50 24	East Roberts	70 04 18	23978.4	26222.1	14.90
			246 31 46	West Roberts	66 43 06	20015.9	21888.8	12.44
Campbell	49 00 08.46	123 33 49.55	274 22 49	East Roberts	94 47 29	40031.7	43777.5	24.87
			275 22 11	West Roberts	95 44 17	35923.6	39284.9	22.32
Galiano, southeast	48 54 14.91	123 20 12.65	123 23 47	Campbell	303 13 31	19884.3	21744.9	12.35
			248 40 44	West Roberts	68 52 34	20561.9	22485.9	12.78
Galiano, northwest	49 00 47.07	123 33 54.59	276 03 43	East Roberts	96 28 27	40242.7	44008.3	25.00
			305 50 21	Galiano, southeast	126 00 40	20644.5	22576.2	12.83
Avenue	49 00 05.57	123 04 52.33	60 02 43	Galiano, southeast	239 51 09	21629.0	23652.8	13.44
			92 15 21	Galiano, northwest	271 53 27	35425.6	38740.3	22.01
Richards	48 56 08.01	123 25 55.11	296 34 48	Galiano, southeast	116 39 06	7796.6	8526.1	4.84
			253 55 19	Avenue	74 11 11	26707.2	29206.2	16.59
Galiano, northwest, Plumper signal.	49 00 48.09	123 33 54.66	305 43 44	Rock	125 54 33	21601.1	23622.3	13.42
			305 54 19	Galiano, southeast	126 04 39	20666.5	22600.3	12.84
Marked tree, northwest, Roberts	49 01 24.68	123 05 30.97	86 16 30	Campbell	265 55 09	34591.8	37828.6	21.49
			51 17 58	Rock	231 07 23	21985.4	24042.6	13.66
House on shore, south end	49 00 37.71	123 05 05.19	17 23 52	Bell's Chain	197 19 51	21850.6	23895.2	13.58
			88 42 09	Campbell	268 20 29	35051.9	38331.7	21.78
Hydrographic signal, 1858	48 59 29.24	123 04 43.73	62 54 20	Galiano, southeast	242 42 40	21246.0	23234.0	13.20
			94 02 55	Galiano, northwest	273 40 55	35661.7	38998.6	22.16
Robertsville, flag-staff	48 59 01.29	123 04 31.17	22 00 57	Bell's Chain	201 56 30	19277.7	21081.5	11.98
			93 29 23	Campbell	273 08 17	35802.3	39152.3	22.25
Disappointment	48 51 20.49	123 14 17.36	127 13 56	Rock	307 09 58	8087.5	8844.2	5.03
			307 36 45	Bell's Chain	127 39 39	5967.5	6525.9	3.71
Forwood	48 54 56.64	123 23 08.29	289 47 40	Galianoo, southeast	109 49 52	3800.5	4156.1	2.36
			129 32 16	Galiano, northwest	309 24 09	17027.1	18620.4	10.58
Marked tree 25	48 56 44.21	123 27 30.03	297 20 21	Galiano, southeast	117 25 50	10025.6	10963.7	6.23
			133 51 07	Galiano, northwest	313 46 17	10834.7	11848.5	6.73

APPENDIX No. 14.

GEOGRAPHICAL NAMES ON THE COAST OF MAINE.

BY REV. EDWARD BALLARD, SECRETARY OF THE MAINE HISTORICAL SOCIETY.

BRUNSWICK, MAINE, *July*, 1869.

SIR: In compliance with the proposals addressed to me June 30, 1868, I have the honor to present to you the following attempt at an examination of the geographical nomenclature of the coast of Maine, for the purpose of furnishing a list of the names of Indian origin, with their proper orthography, so far as it now can be ascertained, and their interpretation; and also names given by early settlers, or others coming from European shores; and when practicable the dates when these latter began to be used as terms of specific designation; and to add such historical notes as may be desirable for the further elucidation of the points thus brought into view.

In regard to the names derived from the language of the aborigines of this territory, difficulty arises from various causes.

The first is found in the changes produced by dialectic departures from the one original language. This language has been properly named the *Abnàki*, derived from the primitive words, *wañban*, *white*, and *ahki*, also written *auke*, land or *place*, forming the compound word *Wañbanahki*.[1] As the light of the morning, before the rising of the sun, was an object of great interest to the wild men of the woods, in the pursuit of their game or their foes, they applied the term *wañban*, in one of its definitions, to denote "the clear morning light;" and then to designate the part of the heavens where it first appeared. Thus, the compound word was used to signify the "east-land," and, as a consequence, it was also applied to distinguish the language. By usage and the tendency of that usage to diminish the number of syllables, especially by foreigners, the name has been shortened to *Abnaki*,[2] though the forms *Abenaki* and *Abenaqui* are sometimes used, with an equal respect for the origin of the name, which was not only adopted by the Indians of Maine, but was also applied to them by their fellow-natives living at the west of their territory.[3]

The name Algonquin has also been adopted to denote this language, which was not only the outlet of thought for the several tribes of the region now known as Maine, but served a similar purpose for all the tribes of New England, the new "Dominion of Canada," and the chief parts of the present States lying north of North Carolina and Kentucky, and those in the Northwest beyond the Mississippi. Indeed, it may be said to have spread over all the North from the Gulf of St. Lawrence to the prairies of the West, with its northern limit bordered by the Esquimaux; excepting from its range the entirely distinct language of the *Hodénosaunee*, "The People of the Long House," known in our history as the Six Nations of the Iroquois[4] in New York, and the tribes residing on the borders of Lakes Erie, Huron, and St. Clair. This name *Algonquin* or *Algonkin* is taken from a small tribe in Canada,[5] and in this wide sense is of only a recent application.[6] It is convenient, as not being limited by a narrow geographical restriction like *Abnaki;* and may well be allowed to keep the place which Indian scholars seem willing to permit it to have.

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[1] In pronouncing this word the Indians add the sound of *m* after the first *ñ*, which Râle introduces in the word *arañmkik*, "sous la terre;" and give a peculiar rush of guttural breath, not to be represented by letters.

[2] Râle's Dictionary of the Norridgewock dialect, Pickering's Preface, in Memoirs of the American Academy, Vol. I, new series, p. 372.

[3] Heckewelder, Hist. Acct. of Indian Nations, pp. 25, 107, 109, 111, who wrote *Wapanachki*.

[4] Morgan's "League of the Iroquois," 1851.

[5] Lescarbot speaks of the Etechemins, the Algoumequins, and the Montagnés as together sending a thousand men against the Iroquois. With an allowable liberty he writes the name differently from the now more common form. *Hist. Nouv. France*, Liv. III, ch. 10. Mass. H. Coll., 2d ser., X, 131.

[6] La Hontan, however, in 1715 gave more than thirty tribes as using this dialect. But his testimony is somewhat marred by including the Esquimaux in the number. Tome II, pp. 36–38.

But while this language is thus widely extended, and perhaps was once used as *one* throughout its whole domain, lapse of time, separation of tribes, diminished intercourse between them, various new circumstances, and the want of all power to fix the language with any approach to permanency by orthographic means, have produced changes in words to an extent that makes the dialects to appear even more than the dialects of ancient Greece, as if they were in reality different languages. As a single instance, reference may be made to the name of *hatchet*. In the Virginia dialect it was *Tamahaak*,[1] whence is derived the name tomahawk. In the Delaware it is *Temahican*. In the Penobscot dialect in Maine it is *Tàmhegan*. In the Norridgewock it is *Temahigan;* in the Micmac, *Tumhegn*. In other words, the variations have become so great that the Indians of the tribe at Oldtown on the Penobscot, and their brethren of the Passamaquoddy tribe at Pleasant Point, though not a hundred miles apart, have great difficulty in conversing with each other; and both these have still greater in understanding the Micmacs of Nova Scotia. If the Norridgewocks, the Sokokis, the Souriquois, the Tarratines, the Etchemins, the Marasheets, and the Almouchiquois, were still as once living in the State, there would be a large measure of the same kind of impediment to intercourse still remaining. Yet their ancestors in remote days had the same language.

In the orthography of the names as well as in their interpretation, a knowledge of the different dialects is required. The means of gaining this knowledge is supplied in part by the labors of the missionaries of early times; among whom Râle is a memorable example of intelligence and fidelity.[2] They have reduced some of the dialects to a written form for the purposes of devotion, with translations. In words which conform to the dialects of Massachusetts and Rhode Island, the labors of Eliot, Cotton, and Roger Williams afford great assistance. Vocabularies of the Delaware, Virginia, and Western dialects also contribute valuable aid.

Another difficulty is found in the *forms* in which these geographical names appear. The Indians knew nothing of writing beyond certain attempts by figures of objects, drawn on the bark of the white birch and prepared skins, to indicate their movements on the march, and record their successes and defeats.[3]

Their words, as caught by the ear of the early navigators and the hardy pioneers in the forest, are presented in different orthographies. In some instances the change has been so great that the original form of the names has been nearly lost, and could not have been recovered but from the fact that the present Indians often retain the ancient name, and thus enable the inquirer to preserve it in accordance with their own expressions. And yet in some instances they do not entirely agree in their own utterances. We find a variation in pronunciation among them, as we also find it in that of our own language. As a single instance, the following changes of the word *oolegan*, *good*, are all equally well understood by the members of the present Penobscot tribe: *Ooregan*, *oolegan*, *owlegan*, *owregan*, *wunnegan*, *winnegan*, *wauregan*, *waulegan*, and perhaps some others. When to this variety of pronunciation there is added the imperfect writing of the early settlers and interpreters, a reason readily appears why the names of persons and places should be clad in several varying forms. In many cases where the existing vocabularies do not afford aid, the present Indians are unable to give an explanation. They refer them to an older language; and this must mean the original language, before it was broken into dialects, where changes have proceeded so far as to show an appearance of a language of a different structure; though the careful student will see the traces remaining sufficient to carry his thoughts back to the common parentage. Or they ascribe them to the temporary influence of other tribes, in fixing some of their words as permanent designations of certain localities.[4]

In determining the meaning of words, necessary aid is found in remembering that the Indians

[1] The word appears to be a compound, from *tehemen*, *to cut*, and *haac*, pronounced *hauc*, an *implement*, *tool*.

[2] His dictionary of the Norridgewock dialect was captured by Colonel Westbrook in 1721. 2 Williamson's Hist., 108. It is preserved in the library of Harvard University, and was published (1833) in the "Memoirs of the American Academy," Vol. I.

[3] The Micmacs had a hieroglyphical mode of writing, different from the pictographic, and somewhat like the Chinese, in which characters represented words and combined ideas. The early missionaries adopted the method and carried it onward to a large extent. New York Hist. Magazine, vol. 5, pp. 289–292. "Micmac or Recollect Hieroglyphics."

[4] The name *Chesuñcook*, denoting a large lake in the northern part of Maine, is one of this class. The Penobscot Indians do not explain it. But with the vocabulary of the Pennacooks, as given by Potter, in the Farmers' Monthly Visitor, Vol. XIII, 323, the meaning is ascertained to be *Great Goose Lake*.

of different tribes, and indeed to some extent in the same tribe, interchanged certain consonantal sounds without any hinderance to the communication of their thoughts. Thus the letters *b* and *p*, *l* and *r*, were used for each other; so were *k*, *g*, and *q*; and *t* was sometimes the substitute for *k*, and even for *q*; while *f* and *v* were not used in Maine, though sometimes appearing in the words as *written* by the new-comers; especially in the case of the latter of these two where *u* and *v*, in the old English custom, were employed as equivalents, as in the name applied to a locality in Maine, and afterward to a large part of its coast—*Mau-oo-shen*, written *Mav-oo-shen*. The Micmacs seem of late to have introduced *f* and *v* in place of *b*. Vowels were easily changed; and the persons who early wrote their words used much liberty in the introduction of such letters as they deemed best for their purpose; and through carelessness allowing *u* to appear as *n*, and the reverse. Letters were also introduced for the sake of avoiding harshness of sound, particularly in the composition of words,[1] formed by taking parts of several and "agglutinating" them into a new form; sometimes taking only a single sound or syllable from the least important, and sometimes extending the union to a length like the following:

"Nukkitteamonteanitteaonganunnonash."[2]

In the termination of words denoting *place*, the syllables *at*, *et*, *it*, *ut*, *set*, frequently appear; and, while used as affixes, have the power of prepositions, meaning *at*, *in*, *near;* also *ak*, *ek*, *ik*, *ok*, *uk;* and *ag*, *aug*, *og*, *ook*; and with *c* euphonic prefixed, *cook*, sometimes becoming *kuk*, *onk*, and *unk* with *l* prefixed, *lunk;* and some others, which will easily be seen to fall within this class, usually called *locative* affixes, such as *eag*, *keag*, *keak*, *ke*, *ki*. Sometimes syllables added appear to have been the termination of a verbal form for the purpose of giving a verbal meaning to the noun to which it is applied. Though they had no substantive verb, they seem to have had some idea of its nature; and by this addition they conveyed the thought of the object *existing* in the place to which they appropriated the name. But the more common derivation for these affixes will be found in the word *auké*,[3] *land*, *earth*, *place;* written in dialectic differences *ahki*,[4] *ohki*.[5] The first syllable under euphonic influences readily passed into *uk*, *ook*, and the other forms above noted, easily recognized as having their origin in this word, and as prevalent among the Massachusetts tribes, and those of its contiguous territory;[6] while in the central and eastern parts of Maine, the *last* syllable was frequently adopted for this use, appearing as *ki*, *ke;* and with *k* as a suffix, having the power of a preposition, making *kik;*[7] and from this, in the English mode of writing, becoming *keag;* which form also appears in other parts of New England. Sometimes, too, from the instinctive desire for euphony, the first consonant *k*, in which the meaning resides, was allowed to disappear, or be supplemented by another, and so was changed to *eag*, *deag*, *seag*, and others.

As the pine-tree was the characteristic growth of a large part of the State, it was but a natural consequence that many localities should be named with reference to this fact. The same is true in regard to the places frequented by the bear. Noted places for catching and drying fish were marked with names to designate these occupations. Thus we see the reason for the frequent occurrence of the same words in the interpretation of these names.

This attempt to explain the following words, as well as to present them in a correct orthography, is the first that has been thus systematically made. In the majority of them there can be

[1] "This language doth greatly delight in *compounding of words*, for abbreviation, to *speak much* in *few words*, though they be sometimes *long;* which is chiefly caused by the *many syllables* which the *Grammar Rule* requires, and *suppletive syllables* which are of no signification, and curious care of *Euphonie*." Eliot, Ind. Gram. in Mass. Hist. Collections, 2d ser., Vol. IX, p. 252.

[2] The language of the Esquimaux is even more prolific in long words. The expression "Lest I be full," (Prov. 30, 9,) is thus translated: "Karsillârnekârnâuviâĉissegallóartonga." But an example by J. Hammond Trumbull, to whose eminent success in Indian scholarship the present writer is much indebted, furnished in a note to his edition of Roger Williams' Key, p. 184, and lengthened beyond all that has yet appeared, "gives, in illustration of 'the Indian way of compounding words,' one of twenty-two syllables, which signifies 'our well-skilled looking-glass makers:'

"*Nup-pahk-nuh-tô-pe-pe-nau-wut-chut-chuh-quô-ka-neh-cha-e-nin-nu-mun-nô-nók!*

"One can hardly look at it without stammering. With a language permitting the construction and use of such compounds as this, the 'man of few words' might yet be loquacious."

[3] R. Williams.

[4] Schoolcraft.

[5] Eliot.

[6] As *ak*, *ok*, *oc*, *og*, *aug*.

[7] Râle's Dict., "Terre." But *auké* is here sometimes retained: as in *K'tahdenauké*, now Mt. *Katahdin; howanochewauké*—white man's place, *i. e.*, house.

but little doubt as to a near approach to accuracy in both particulars. Some are involved in an obscurity which further investigation may remove.

A few English local names, as before mentioned, are added for the purpose of referring to their origin, and, as far as may be, to the times and reasons of their application to localities well known.

Trusting that this effort to illustrate the geographical names on the coast of Maine, as to their orthography, meaning, and history, will be acceptable and prove beneficial to your Department, I have the honor to be, very respectfully, your obedient servant,

EDWARD BALLARD.

Prof. BENJAMIN PEIRCE, *L.L. D.*,
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GEOGRAPHICAL NAMES ON THE COAST OF MAINE.

ABAGADUSSET.—This name is given to a river and a point on the north side of Merrymeeting Bay. The original name of the point was *Nagusset.*[1] At a later day it was called "Point Agreeable." Among its several forms occurs *Bagadasset;* which agrees with the word *bagadassek*, given by Râle under *eclairer* to *shine;* who also under *soleil* gives *pagadassem, il eclaire, i. e.*, the sun shines. It is not known whether the river or the Indian chief of early days first received this name, which was probably taken from the reflection of the sunbeams on the waters of this broad inland bay. This sagamore, jointly with Kennebis, of Swan Island, deeded land to Christopher Lawson, of Boston, October 8, 1649, who built a house and dwelt on the western side of the Kennebec, below the bay, and afterward sold to Thomas Lake, but in such a way as to be deemed to have conveyed no title.[2] This chief appears to have been peaceful, like "The Shining Sun."

But another mode of writing the word *Abeguaduset*, suggests a preferable interpretation, from the word *begwâtus*[3] *bay.* It may refer to the large expanse of Merrymeeting Bay, or to the broad opening of the river bearing the name at the head of this article. Dropping the first letter, probably an English prefix, and using the locative *et*, the word finds its equivalent in *At* the Bay, as the place where the chief has his home.

ACQUEHADONGONOCK.—This word denoted a point on the west side of the "Chops," *Kebec*, where the Kennebec leaves Merrymeeting Bay in its progress to the ocean. It is derived from *Ughiadi*, to finish, terminate; *agŵañn, dried*-fish, (Râle,) *augowam* and *auguan*, (John Smith,) *smoked fish*, and *ock*, a *place.* The full form will, therefore, be *Ug-hi-ad-an-gwañ-ock.*[4] The form given at the head of this article is found in the ancient maps of the Pejepscot Company, now in possession of the Maine Historical Society. The accepted interpretation of the name is Smoked-Fish-Point.

AGAMENTICUS.—This name was given by the Indians to the stream now called *York River*, at the mouth of which Sir Ferdinando Gorges planned to found the city which was called "Gorgeana," and incorporated by him by a grant in 1642. Thence it was appropriated to the mountain near its source, called by Captain John Smith "Sassenowe's Mount," and by the Prince his Highness, "Snodon Hill." It is derived from the form of the little pond in the town of Eliot, at its head, which is much like that of the Indian snow-shoe, *añghem*, plur., *anghemak.*[5] The last syllable is the same as *koos*, a stream, from *kesoose*,[6] to *run*, or *koosihada*,[7] to *run* down. The full form of the word, therefore, was *An-ghem*-ak-koos, with the euphonic syllable *ti* interposed to make *An-ghem-ak-ti*-koos, meaning "Snow-shoes River," or "Raquette River," as in the Adirondack region of New York. By the softening process of usage it has come through various orthographies to its present form, *Agamenticus.*[8]

ANDROSCOGGIN.—The present form of the name borne by this important river, improperly

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[1] So says tradition, confirmed by documents in the Pejepscot Papers, Vol. 1, p. 105. S. Davis, p. 491ª, Cossen's deposition. Maps in same, 50 and 54ª, 1719.

[2] Pejepscot Papers, Vol. 1.

[3] See Castine.

[4] *Ock*, or *auk*, from *auke*, land.

[5] Râle under *raquette lac.* When a bay in a lake was described, the word was *wañriañghemak.* The word is derived from *añgmakou*, the ash-tree, of which wood the curved rim was made.

[6] In the *Kimzooi Awikhigan.*

[7] Râle under *avaler.*

[8] John Smith wrote it *Accominticus. Ahkeekwontep. Seal Head* on Fox Islands; *ahkeek-seal, upakwontep, head.*

reports its original, *Amoscougan*, as it appears in "The Indian Perepole's Deposition."[1] It has been thought to have been given in compliment to Governor Andros,[2] who had taken an active interest in the affairs of Maine for several years, beginning as early as 1677. But the name appears in an instrument for the conveyance of the right of sovereignty over a large tract of land on both sides of the river, from the falls at Brunswick, by Thomas Purchase, to John Winthrop of Massachusetts, in 1639. Perhaps the influence of Andros in the province had the power to perpetuate his name in this connection successfully over the other sixty forms in which it has been written, according as its sound was received by the ancient hunters, owners, and settlers. There seems to have been a disposition to make it conform to known words in the English usage. The name "Coggin" is a family appellation in New England; and it was easy to place before it, according to each man's preference, other familiar names, and to call the stream "Ambrose Coggin," "Amos Coggin," "Andrews Coggin," "Andros Coggin," and "Andrus Coggin." Its derivation is from the word *namās*, *fish*, abbreviated, as is the frequent practice, by dropping the first letter, and *skaouhigan*, (*skowhegan*,) a fish-spear. Under the word *poisson*, Râle gives *kankskaouihigan* as a *trident*, or the long piece *of iron in the middle of it*. The last part of this word denotes the iron point between the two outer portions, each of which is called *ĕnegahquok*. The syllable *kaňk* is the line that draws the flexible sides together.[3] This part of the word is retained as a local name originally applied to the falls at *Skowhegan*, on the Kennebec, just below which the waters have long been frequented for torch-light *spearing*.[4] The name, as furnished by Perepole with his description, marked the part of the river above the *Amitigonpontook*—that is, the "Clay-land Falls" at Lewiston; upward to "Arockamecook"—that is the "Hoe-land," at Canton Point. The rips and shallows in this portion were favorable for *spearing fish* beyond any part below. The name may, therefore, be translated the *Fish Spear*, or Fish *Spearing*.[5]

ATKINS' BAY is the expanse of water near the mouth of the Kennebec, between Hunniwell's Point, on which Fort Popham stands, and Cox's Head. It takes its name from an owner of the adjoining territory, who was an original settler,[6] and afterward sold his property to William Cock,[7] in 1662, consisting of 1,300 acres of land, of which the first existing map was made in 1731.[8] It is without doubt the aboriginal *Sabino*, which will be explained in its proper place. Mr. Atkins had ten daughters, and the fact that in the transfer of property after his decease they all signed the deed with their marks shows the studied inattention to female education in the laws of Massachusetts, from the south shore of which State Mr. Atkins came, and to which he appears to have removed after the sale of his land.

BEDABEDEC,[9] (*Be-da-be-da-ki.*)—The original name of the region about "Owl's Head." The word is first seen in Champlain, who describes it as "a low land," (*une terre basse*,) and the cape as "La Pointe de Bedabedec." The derivation of the name is somewhat conjectural; but it appears to come from *nĕbe*, *water*, abbreviated and repeated; *da*, interjectional, *there*, to indicate admira-

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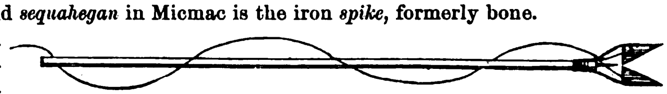
[1] Maine Hist. Coll., Vol. III, 333, taken from the Pejepscot Papers, Vol. 1, 504ᵃ. Perepole is Pierre-Paul.

[2] Webster's Dictionary, p. 1629.

[3] Compare *skahaňgan*, *bois fourchu*, in Râle, and *skahogan*, a "forked post," in "Kimzowi Awikhigan," the *o* having a nasal sound; *sekowhegan* in Penobscot and *sequahegan* in Micmac is the iron *spike*, formerly bone.

The application of the parts of this word will be more apparent from the following representation of the spear as used now. The wooden triangular pieces of wood open upon the springs when pressed on the fish, and the iron spike pierces him. As the triangles spring back the line is drawn and he is secured.



[4] Lithgow's Deposition. Pej. Pap., Vol. 1.

[5] In an account of places on the coast and interior, with their names and distances, Purchas gives *Mas-sa-ki-ga*, which, from its position in his statement, was on the Kennebec. The full form of the word would be *Na-mās-sa-ke-gan*, (*namās*, *fish*.) This is sufficiently like the present name to show the nearness to certainty that it denoted the same locality as the present name of the falls on the Kennebec at *Skowhegan*.

[6] He attended a meeting for settling a government on the Kennebec, May 23, 1654. Hazard's Coll., I, 585.

[7] From him came the name Cock's Head, now Cox's.

[8] Pej. Pap., Vol. 6, Map 52.

[9] Ch. III, p. 62, edit. 1632. See Jeffery's maps. Champlain speaks of the mountains of "Bedabedec," p. 67, evidently meaning the Megunticook Range at Camden, called by Colonel Church, in his Indian Wars, "The *Mathebestuck* Hills," and by John Smith, nearer the beginning of the same century, (1614,) *Mecaddacut*, "against whose feet doth beat the sea." Mass. Hist. Coll., 3d ser., Vol. VI, 117. Church's narrative, 141. 2, Williamson, 95.

tion, repeated for emphasis, and *ki*, land or *place; water-there! water-there! place;* which in our language may find its proper expression in "Cape of the Waters" or "Cape of the Ocean." The Indians translate "Owl's Head" into *Co-co-cas-wantep-uk*, from *co-co-cas*,[1] *owl*, (*kookookasoo, chat huant*, Râle,) and *up-pak-wantep*, head, and *uk*, a locative. On Smith's map of 1614 it is "P. Travers."

BUNGANUNGANUCK, commonly shortened to *Bunganuck*.—This small stream, flowing into Maquait Bay, runs at the bottom of a deep ravine, the deepest for a long distance on this part of the coast, and on this account became to the natives a fit object for a special designation to indicate that feature. In one of the cognate dialects the word *Pank-han*-nunk denotes *under the bank*, from *pank-han-ne*, a *bank*. *P* and *b* are often interchanged, and vowels oftener. Thus this word receives an explanation in perfect accordance with the high and steep *banks* on both sides of the stream, which seem to be more emphatically described by the repetition of the syllables *ungan*.[2] It may be represented in English by "High-bank Brook."

CAPE ELIZABETH.—The date of the discovery of this cape, and the person by whom the name was given, are not known. The first appearance of the name is on John Smith's map, 1614. The Indian name was *Apistama*.[3] The present one may have been given by Gosnold in 1602, or Pring, more probably in 1603. Gorges reports of him that he "brought with him," on his return, the most exact discovery of the coast that has since come into his hands.[4] The Queen reigning at the commencement of that century has her name here permanently fixed on this prominent headland of Maine.

CASCO, (*kasko*.)—This bay, early known as the *Archipelago* of Gomez,[5] bears a name easily interpreted. The word *kàskou* appears in Râle's dictionary under *oiseaux* without any equivalent In the "Kimzowi Awikhigan," *kasko* is *crane*, and the present Indians give the same explanation. In early maps and writers it appears as *Koskebee, Kaskebee, Cascobé*, which forms are easily resolved into *kasko-nebe*. The abbreviation of the last word, as is usual in composition, helps to make the word *Casco-be*, to be translated *Crāne-water* or *Crane* Bay. An early name was *Aucocisco*, as seen in Smith; probably pronounced *Uh-cos'-is-co*, the first syllable being deeply guttural, and was written as the hearers caught the sound. The crane or heron still frequents these waters.[6]

CASTINE was named from the Baron de St. Castine, who occupied the place of the present remains of the old fort near the water of the bay, a short distance from the town, and on the spot where the Plymouth Company from Massachusetts had a trading establishment in 1626. D'Aulnay erected his fort some years later, (1635–'40.)[7] Castine came about 1665.[8] The place had been formerly known as *Bagaduce, Bigaduce*, and indeed by a variety of similar sounding names, among which Major Biguyduce, erroneously supposed to be the name and title of a French officer once a resident there, came nearer than the rest to the original.

Matche-be-gwâ-toos.—Màtche is *bad*, and *be-gwa-toos* is *bay*. In the explanation by the Indians the name marks a place in the harbor of Castine, where, when the tides from different entrances meet over sunken rocks, the navigation is so difficult and perilous for their light canoes as to suggest the name of Bad Bay.[9] Purchas gives *Chebegnadose*, which omits the first syllable *mat*, and by an easy error gives *n* for *u*.[10]

CATHANCE.—This winding river runs into Merrymeeting Bay on the north side. The word *ka-*

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[1] Zeisberger, in the Delaware dialect gives *gŏk-hos*, *g* for *c*.

[2] Eliot, Gram. p. 17. R. Williams, Key, Trumbull's note, 208.

[3] Williamson's Hist., Vol. 1, p. 30, note. It was also called by the Indians *Semiamis*, R. H. Major's note in Strachey Caput IX, Aug. 28, 29. These two names were probably attached to two different points of the same projection.

[4] Brief Narration, Ch. V. The way in which Smith, and after him (Levett,) in 1623, introduce the name, shows that this cape was already a recognized point, (Me. H. Coll., Vol. II, p. 86.) The death of Elizabeth, in 1603, would seem to be a reason for the naming of the point by Pring, rather than by Smith many years later. See Smith, Mass. H. C., Vol. VI, 3d ser., and Map, Vol. III, 3d ser.

[5] Me. Hist. Coll., 2d ser., Vol. I, p. 299. Ribero's map, 1529.

[6] Willis' Hist. Portland, p. 15.

[7] Williamson's Hist., I, 308.

[8] Me. Hist. Coll., Vol. VI, p. 111.

[9] Râle "noms" writes it "Matsibigwadoosek, la riviere, ou est Mr. St. Gastin;" the word is the *same, matsi, bǎd*, with the locative *ek*.

[10] Pilgrimage, Vol. IV, p. 1674.

thans in Quinnipiac dialect of Connecticut is translated *seas*.[1] But this supplies no aid here. The word is explained by the Indians as *bent*, *crooked*. They pronounce it *Kat-hah-nis*. Another river of the same name is found in the eastern part of the State, near Dennysville, of the like winding character.

CHAMCOOK is the name of a short range of mountains in New Brunswick, on the eastern side of the St. Croix, which takes its name from the narrow part of the river, known to the natives as *K'tchamcook*, from *k'tche*, great, the abbreviated *namas*, *fish*, and the locative *cook*. The meaning is *the great fish-place*, of which the reputation still continues.

CHEBEAG, erroneously written *Gebeig*, *Jebeig*.—The analysis of the full word would be *k'tche*, *great*, *nebe*, abbreviated *water*, ak, a locative, making *K'tchebeak*, *Great water-place*. From the heights of this large island the ocean view is very extensive.

CHEPUTNATICOOK.—This name of the upper part of the St. Croix is probably taken from one of the boundary lakes. It has been said to mean Great-Hill Lake.[2] Its long and narrow form, like a wide river, is bordered on the west by a range of abrupt and elevated ridges, covered with a heavy "black growth," chiefly spruce, and might well suggest this explanation. But in dividing the word into its parts, *K'tche-put-natic-ook*, and finding in a cognate dialect the word *nataque*, *(nătăk,)* beaver, it would seem to refer to an abounding place for this animal. The second syllable, *put*, is still obscure, as is indeed the meaning of the whole word. It is often shortened to *Cheputnacook* and *Cheputnook*.

CHEWONK, from *k'tche*, *great*, *w* euphonic, and *onk*, a locative, finds its equivalent in *Great Neck*.

CHICKAWAUKEE, a pond supplying the city of Rockland with water, *k'tche*, *great*, kooĕh, *pine*, *auke*, *place*. The first part of the second word is taken to make *K'tche-koo-auke*, representing *Great Pine Lake*.

COBSCOOK would be more correctly *Cob-os-se-cook*; from *cob'-os-se* or *cab'-os-se*, (kabassé, Râle,) and *cook*, a locative, equal to Sturgeon River. A similar name, *Cobosseecontee* or *Cobosseconticook*, is the name of the mouth of the valuable mill-stream at Gardiner, where this kind of fish anciently abounded.[3] The stream itself was called Sq-uagŭset, implying that some important Indian dame had once dwelt on its banks.[4]

COX'S HEAD.—For the origin of this name see ATKINS' BAY.

COWSEAGAN.—This narrow passage near Wiscasset bears a name corresponding to the word *koussigan*,[5] denoting an Indian mode of kindling fires, with certain forms and ceremonies, for the purpose of foretelling future events or ascertaining about the absent in war or in the chase; whether they are living or dead. Perhaps this neighborhood was the place where this was often done. The Indians explain it as "Fortune-telling."

DAMARISCOTTA.—This was Tamescot in Heylin and other early writers. The present Indians call the river *Matamascontee;* a name also of a tributary of the Penobscot in the northern part of the State. They explain it in reference to successful fishing. The analysis of the word denotes that a certain kind of fish, at the proper season, were abundant in the tide-water below the steep falls, up which they went into the fresh-water pond, a short distance above, for increase. The component parts of the word are *mahdāmās*, *alewife*, and *kontee*, implying *plenty*, making *mahdamaskontee*. In the other stream of this name, this kind of fish has ceased to appear, being hindered by mill-dams below. The present name of the river and town, sometimes divided into two parts, seems to have been deduced from a desire to make the native words assume an English form. John Cotta married into the family of Richard Wharton, one of the large landholders in Maine, and received here a tract of land as the heritage of his wife. At an earlier date some one of the name may have resided on the river, or been well known as in traffic with the settlers on its banks. Possibly some one of the family may have borne the name of Damaris. At all events, the name *Damaris Cotta* was more agreeable than *Matamascontee*, or *Tamescot*, its abbreviation; and, thus gaining the

[1] Trumbull's note in R. Williams' Key, p. 33. Note 18, in MS. letter referred to Eliot's *kehtahhanash*, *seas*. Neh. 9, 6.

[2] Springer's Forest Trees and Forest Life in Maine, p. 179.

[3] Lithgow's Dep. Hist. and General Register, Jan., 1870, p. 23, *where it* is *Cawbisseconteague*, and explained, "Sturgeon-land."

[4] MS. map, supposed to have been made by Colonel Church, in reference to the "Second Indian War," 1688–97. It is preserved in the State Archives at Hartford, Connecticut.

[5] Râle's Dict., *Jongleur*, *Jonglerie*.

ascendency, has prevailed to the present day. The family name of "Cotter" is found there still. The immense heaps, or rather hills, of oyster-shells, showing the action of fire, are a proof of the former abundance of this bi-valve in this stream, and the long continued visits or permanent dwelling of the Indians on both its banks. In Jackson's Geological Report the quantity is estimated at 44,906,400 cubic feet of shells, capable of producing 10,000,000 casks of lime of the usual dimensions.

DAMASCOVE, Damarin's Cove, or Damaris Cove, could hardly have been derived from Damaris-cotta, for the name "Damarill's Isles" is found in John Smith, (1614,) and suggests that these names had a different origin. The word seems to have included if not describing Pemaquid Bay.

DOUAQUET.—See JORDAN'S RIVER.

EBENECOOK, now the name of a harbor northwest of Southport Island, was probably the name of the island itself. If it were *Ebemécook*, and perhaps it was, it would mean *High-bush-cranberry-place*. *Ibcmènécook* means *Choke-cherry-place*. Another explanation may be suggested from the Passamaquoddy word *munigu*, an island, and *ook*, *place*, making *Muniquook*, or, as otherwise, *Menikŭk*, changing *m* to *b*. Thus it would be Bĕnēcook, "The Island," easily changed to the present form.

EGGEMOGGIN, *Edgmoggin*, *Edgmorragen*.—A reach between Deer Island and the towns of Sedgwick and Brooklin. The Indian word *āgāmoggin*, *snow-shoes*, may be the correct explanation of this name, having some allusion to this "Reach" which is not now known.

FRENCHMAN'S BAY derived its name from the settlements on the grants made on its borders, to Mons. Cadillac, from Louis XIV, in 1691, to confirm the possession of what was claimed to be Acadia. His granddaughter, Madame Gregoire, in 1787, acquired from Massachusetts a partial confirmation of the original concession.

HARRISEEKET was the name of Freeport; probably denoting the broad part of the river nearest Casco Bay. The word *hallaseget* means to cut with a knife, and is used with regard to cutting fish. An Indian explains it as *Dress-fish-place*.

HIPPOCRASS, improperly Hypocrites, "spiced-wine,"[1] a name probably given to this island by jolly seamen.

HOCKOMOCK.—A story of the Indian times, connected with this headland, implies that the word means "devil." But the dialectic names for the "evil spirit" were *matsi-niwesko*, and *matta-dewando*, contracted to *tanto*. In the Massachusetts language, or rather dialect, it was *hobomock*. The present word should be written *Honckamock*, from *honck*, a *goose*, *am* euphonic, (unless it is an abbreviation of *namās*, fish,) and *ock*, *place*. As applied to the water, as would be natural, it is the equivalent of *Wild-Goose-Bay*. This is one of the words that show how the Massachusetts dialect, in the word *honck*, had an influence in Maine. Where in the Norridgewock for *goose* was *awérér*, in the Penobscot it is *wompato*, and in Etchemin, *wahbegeel*.

HOG.—The name of an island in Portland Harbor, shortened from *quohog*, or, as given in Webster's Dictionary, *quahaug*, the *round clam*. The word is often pronounced *co-hog*. In Massachusetts it was written *quauhaug;* and in Narraganset *po quau-hock*. Râle wrote *pe-kwa-hak*, which he applies to *oysters*. The original word is thought to mean "a tightly closed shell."

When Christopher Levett visited the waters now known as Portland Harbor, in 1623, he reported it as "Quack," probably with the broad sound of the vowel, and gave the place the name of York, where he intended to found a city.[2] One acquainted with the local pronunciation can easily see how the change was made from the original Indian word.

HUNNIWELL'S POINT.—The name of the person whose name is attached to the point of land between Atkins' Bay and the ocean, at the mouth of the Kennebec, appears in a document dated May 18, 1672.[3] The place where his house stood is indicated on a pen-drawn map among the Pejepscot Papers.[4] The cellar still remains.

ISLE AU HAUT.—This mountainous island received its descriptive name from Champlain, in 1605, when, with De Monts, he coasted from the St. Croix to Cape Cod. It has a small settlement

[1] Webster's Dict. Williamson's Hist., I, 56.

[2] Me. Hist. Coll., II, p. 84. Willis' Portland, p. 26.

[3] Me. Hist. Coll., V, 240. His name is there signed Ambrose Honeywell. His house was standing in 1731, owned by J. Lewis.

[4] Vol. 6, Map 52.

on the northeastern side, and a few scattered houses in other parts. The old French mode of writing the last word was "hault." This form appears in the present usage of the residents in that region, who call it "The Isle of Holt." Williamson recognizes the same form. The Indian name, Soolĕcook, is translated *Shell Place.* Smith noticed this mountain-island as one of "the remarkablest" landmarks, and wrote, "The highest isle is Sorico, in the bay of Penobscot."[1] The word is the same with the one given above, with a dialectic change by the Coast Indians of *l* to *r*. With the proper termination it would be *Sorĭcoke* or *Sorĭcook.*

ISLESBORO'.—Of this the Indian name is *Betowbagook*, which denotes its position between two channels.

JEREMISQUAM.—The Indians sometimes had English names given them by the early settlers and missionaries. In this region there were Sheepscot John, Robin Hood, (Darumkin,) Daniel Robins, (Ninemewet.) This name marks the name of one who bore that of the melancholy prophet, with the word *wigwam, house,* shortened by the English comers to *quam*, and then softened to its present form. *Jeremys-House* in this new mode was made to extend its name to all of Westport.

JORDAN'S RIVER, north of Mount Desert, and connected with Frenchman's Bay, was originally *Douaquet*, of which the meaning is not ascertained.

KEBEC is the same as Quebec, the French form of the word, meaning *narrows.*[2] Here it denotes the passage, where the Lower Kennebec leaves Merrymeeting Bay, called "The Chops." This name appears on a pen-sketched map, made about 1690, preserved in the archives of Connecticut, at the State-house at Hartford, and supposed to have been drawn from memory and conjecture by Colonel Church, as an aide to the commissioners of New England in preparing for the Indian war about that time. In Perepole's Deposition,[3] referred to under "Androscoggin," it is given *Quābăcook.* This is the same word with the addition of the locative *ook.*

KENNEBEC.—Of the thirty different forms in which this name has been written, *Kennebeké* is probably the most correct. Divided into its parts, it will be *kenne* or *quenne, long, nebe, water, ke,*[4] *from.* The meaning is "*From the long water*," that is, "Moose Head Lake," which on Mitchell's map is called *Chenebesic*, or *Great Lake.* Its characteristic is length rather than breadth.

KENNEBUNK[5] is of similar origin with the foregoing; *kenne, long,* abbreviated to *ken, nebe, water,* and *unk*, a locative, *Long-water-place*, and properly so named, as the opening of the Kennebunk River is much the largest bay and best harbor for some distance on the coast.

KOWAHSKITCHCOOK.—There is a difficulty in knowing what is the proper word here to denote Machias River. It is called *Kowasskitchcook*, and this would mean *Pines-great-place*, referring to the upper falls. Also, with more probable correctness, *Kwapskitchcook*, which the Indians call *Rocky River*, to the two falls on which this designation is appropriate. The word *penops, rock,* will furnish a part of the first syllable, *k'tche, great,* the second, and the last is the locative. *Kw* is obscure, perhaps for *kooé, pine.* But *kowopscoo* means sharp-rock-ridge. This may refer to the sharp rocks in the rapids.

LEJOK is a name appearing on a map in Jeffrey's collection, near Blue Hill Bay. The name is remembered in the neighborhood, and some years ago it was given to a ship built at Ellsworth by Mr. Black. In one of the cognate dialects *lechauwak* denotes a *fork.* Perhaps it was applied here to mark two diverging branches of these waters.

MACHIAS.—The original word was *Machisses*, properly *Matchesis*, from *matche, bad,* and *sis*,[6] diminutive. *Bad, little,* i. e., *place* or *falls;* and was properly applied here, because, by reason of

[1] Description of N. E., 3d ser., Mass. H. Coll., Vol. VI, 120.

[2] *Kebec*, qui est un détroit de ladite riviere de Canada. Lescarbot, Vol. II, Ch. XIV, p. 307–(327.)

[3] Me. Hist. Coll., Vol. III, p. 333.

[4] Râle, p. 554, (18, 19.) He gives, ("noms" p. 493,) *Aghenibekki*, la riviere *Aŭmesoukkanti*, which is a branch of the Kennebec, taking its name from the falls at Farmington, written on an ancient map in the Pejepscot Collection, Vol. 6, Map 50, 1719, *Amosequonty;* also elsewhere written in a dozen different ways, of which *Amasaconticook* is the one to be preferred, denoting Fish-plenty Place. The stream is "Sandy River;" in the Indian translation, *Penobsquisumquisebo*. It is not easy to understand what meaning Râle's brief note is intended to convey. The present name is like the earliest, having been called *Kinibequi* by Champlain, in 1605–'6, and Biard, in his relation in 1611. Perhaps a thorough analysis of *Aghenibékki* would show it to mean a tributary to this main river.

[5] In Folsom's "Saco," from an old MS., *Kennibonke.*

[6] Vetromile's "Alnambayuli Awikhigan," 443.

the very narrow, winding passage between the crags of the water-course at the lower falls, no canoe could pass through. *Bad-small fall* contrasts it with the larger one about seven miles above, at what was probably the *Kwapskitchcook*, *Mahjais*,[1] which is but a different writing for *Machias*, is explained by *Bad-way*.

MAGOCOOK.—A bay extending from the mouth of Freeport River (Harriseeket) to Flying Point.

MAGUNCOOK, the early name of "Mousam River,"[2] has the same origin and meaning as *Megunticook*.

MAQUAIT, from *maqua*, a *bear*, and the locative ending, *it*. *Bear-Bay* will well represent the meaning of the word, and the presence of this animal in its neighborhood in early days; though more strictly it may show where the natives went *at the bear*.

MATINIC.—John Smith mentions the three isles and a rock of *Matinnack*.[3] The name may possibly be explained like the next. Another form of the word is *Metenic*.

MATINICUS.—Smith refers also to this island, and says, "Metenicus is also three plain isles and a rock betwixt it and Monahigan."[4] The Indians call it *K'nahgook*, and explain it as "Long Island." This word may be from *kenne*, *long*, and the locative termination *cook*.

The one or the other of these two neighboring islands appear in the history of this coast as early as 1609, the year after the colony under George Popham, at the mouth of the Kennebec, broke up and returned to England. In that year his fort, St. George, was re-occupied by a company engaged in fishing, under a leader who treated the Indians with much harshness and injury. In retaliation for severities such as they had never received from the kind treatment of Popham, they took advantage of a favorable opportunity, killed a portion of the English, and by their intimidations compelled the rest to abandon their enterprise here, and select a new point for their efforts, at a place which they called Emmetanic. In 1611–12 Captain Plastrier, in the French service, in attempting to go to the Kennebec, was taken prisoner by the English, with two ships, and carried to their station, "at an island called Emmetanic,"[5] thus asserting English supremacy in these waters. This name, and the occupation for which the English sought this island, leads to a partial indication of its meaning; *Amatanic* suggests *namās*, *fish;* the next syllable *tan* may come from *otan*, in the Narraganset dialect,[6] and *odāne* in the Norridgewock, meaning village. The name "Fish-Town" will not be inappropriate to the location. The terminal syllable in *Matinicus* is not explained.

MAWOOSHEN.—This was a name by which a part of the coast of Maine east of Cape Elizabeth[7] was known to early writers, some of whom wrote it *Mavooshen*, (*v* for *w*,) *Mawoshen*, *Moasham*, and *Mawashen*. This last mode nearly corresponds with the Penobscot word *maweeshen*, which, with a common locative, denotes *Berry-place*, descriptive of several localities near the coast; *Maweeshenook*.

MEDOMAC.—Also written *Madaamock* and *Madahumic*.[8] This variation suggests the form *Matta-am-ock ; matta-not*, *namās*, *fish*, *ock*, place; implying the part of the river where the ocean *fish* are not found, as not being able to pass above the tide-water over the *falls* called *Chegewunnussuck*,[9] just above the village of Waldoboro.

MEDUNCOOK.[10]—A tide-river separating Cushing from Friendship, and connected with Muscongus Bay.

MEGUNTICOOK.—One of the Camden Hills, taking its name from the small river with falls near its base. The word is elsewhere found as Ammequunticook, resolvable into *namās*, *fish*, *konte*, plenty, *cook-place ;* and may be uncouthly rendered as *Fish* plenty river. The Indian village near

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[1] Cadillac, Memoir in the Hist. Coll., Vol. VI, p. 279, says: "Majaïs.—The entrance of this river is difficult on account of rocks, which are concealed at high water." The difficulty, however, is at the falls.

[2] Williamson's Hist., I, 26.

[3] In Mass. H. Coll., 3d ser., Vol. VI, 120.

[4] *Ibid*

[5] Caryon's edition of the Reports of the Jesuits. 1864, Paris.

[6] R. Williams' Key, p. 3, Râle, "Village."

[7] Gorges' "Brief Narration," B. II, Ch. VII.

[8] Pejepscot Papers. Records, I, 88; VI, map and paper of 1738.

[9] Pejepscot Maps. This word is also written *Magowmannussuck*.

[10] Williamson's Hist., I, 59.

the falls, "at the foot of a high mountain, against whose feet doth beat the sea," was known to John Smith as *Mecaddacut*, which represents the sound of the name as he caught it.[1]

MENAN, from *menahan, island*, by emphasis here, *The Island*, as being the largest, and on the maps "Grand Menan." In the Jesuit Relations it is called *Menano*, perhaps *Menanoke.*

MENÀNA, from the same word, with a suffix thought to denote separation, as *The Island*, separated from Monhegan. Smith wrote it *Monanis*, suggesting a diminutive, *Small Island.*

MERRICONEAG was originally applied to mark the "carrying-place" on Harpswell Peninsula or Neck, where a short space in one part of this long and narrow tract separates the waters of Casco Bay from those on the east side of this neck. It was often used in early times by the Indians, and is occasionally used by them at the present day. On the west side was a burial-place of the natives, which was discovered a few years ago in plowing, when several skeletons were exhumed, with wampum, copper ornaments, and axes of European make. An Indian company soon afterward passed across, and spoke of it as a well-known place for crossing, and knew of the burial-ground from long tradition. The word in full would be *Merrucoonegan*, from *merru*,[2] *swift, quick, c* euphonic, and *oonegan, portage.* As the portage at Winnegance was considerably longer and very steep, this, by contrast, could be well called *The Quick-Carrying-Place.*

MERRYMEETING BAY.—This name is said to have had two origins; one from the meeting of the waters of five rivers; and the other from a meeting of surveyors and their enjoyment of the occasion on its shores. But it may have been named from any other similar gathering at the house of the first settler, Thomas Purchase, about 1625–'28, or at any later time.

MONHEGAN.[3]—There is a difficulty in translating the name of this island, called St. George by Captain George Popham in 1607. Comparing it with the definition of Michigan, given by Schoolcraft, from a dialect of the language that reached to Maine, a clue may be found for its interpretation. *Mona*[4] and *munnoh*[5] mean *island. Mona-hegan*, changed by use to *Monhegan*, may perhaps mean "The Island of the Sea." Its position, if not this explanation, well entitles it to this distinction.

MONSEAG.—In the interpretation of the inscription on the Dighton Rock, *Chinkwalk*, at Mackinaw, gave to Schoolcraft *moris*, at the *loon.* The terminal syllable is for *place*, and the compound word may be rendered "Loon Bay," *Moosebeck*, or *Moosabeck.* There are other places on the eastern coast, in which the word *moose* occurs; as "Moose Cove," "Moose Neck." Perhaps this name is similarly formed, *moose-nebe-ki, i. e., moosbeki*, to indicate the place where the animals came to the water. As this name was written by Colonel Allan, 1777, *Mispeckï*, we have an aid for this form, which means *Moose-water-place.* But an Indian explains it thus: *Moosabekik*, a *wet place;* and as Râle, under *mouiller*, gives *mousabégat, it is wet*, and *ne-moussebegh-esi, I am all wet*, this must be taken as the more probable interpretation. But it requires an acquaintance with the locality to see its applicability to this narrow strait more than to other places. Perhaps there is a peculiarity in the tidal flow which made it a proper appellation.

MOUNT DESERT.—The Indian name of this island, as given by the natives in Biard's Relation, was *Pemetiq*, from *pemé'te, sloping*, and *ki, land.* It probably denoted a single locality, which the visitors understood as the designation of the whole territory. The vessel bearing him and his company made their first harbor at a place on the east side of the island, which they called St. Saviour, (Bar Harbor.)

In 1605 Champlain gave its several high elevations the name of "Monts Deserts," which well describes their barren appearance. They were doubtless seen by the earlier navigators, though not represented on their maps, unless under the general name of "les Montaignes," or "Montanas," on this part of the coast.

The earliest historical events on this island are those connected with Biard and his company of Jesuits in 1613, who were proposing to go to *Kadesquit*, (from *kaht*, micmac for *eel*, denoting *eel-stream*, now called *Kenduskeag*,) at Bangor, for the purpose of forming a religious settlement with a

[1] Third ser. Mass. H. Coll., VI, 117.

[2] Potter's Vocabulary.

[3] Also, among twenty other forms, *Menahiggin, Monahigan*, (Smith.) The first refers the word to *menahan*, island.

[4] C. A. Potter on the language of the Pennacooks of New Hampshire.

[5] Eliot, Rev. 6, 14, etc.

missionary design, under the auspices of Madame de Guercheville, of Paris. While they were tarrying at their first harbor, they were visited by a party of Indians who persuaded them to make their abode at the home of Asticou, their chief, on the west side of Soames' Sound, at a place whose *sloping* surface toward the ocean renders it probable that this was the real *Pemetiq*. In the same summer Argoll, an English captain, with an armed vessel, had come from Virginia to procure the annual supply of cod-fish at the islands of Pemaquid. He there learned that the French had taken possession of territory claimed by the English under the charter of James, in 1606. He sailed thither immediately with authority from Governor Dale, of Virginia, for the purpose of their expulsion. With little resistance he captured the scarcely finished defenses and took all the company prisoners; whom he treated with a severity not at all needed to vindicate the claims of his government for the sovereignty. Here was the first blood spilled in the long contest between these two nations for supremacy on the North American continent.

The ocean views and the picturesque mountain scenery have made this island a favorite place of summer resort.

Its name in the Penobscot dialect is *Ahbăsauk*, which is the equivalent of *Clam-bake Island.* At the present day there are high banks of clam-shells near the mouth of Soames' Sound, from which the early settlers took away boat-loads to burn into lime. Similar banks are found at Hull's Cove, Indian Point, and several other places; reminding one of the oyster-shell banks at Damariscotta. The living clams are plentiful in all the coves of the island; and a considerable business is carried on at Bar Harbor and Indian Point, during the spring and autumn, in digging them for sale.[1]

The Indian tradition is that "long time ago, two, three hundred years or more," their ancestors gathered here for the purpose of feasting on this food. The facts in the case show their skill in fixing the name, which tells of their need and the enjoyment of their semi-annual visits to the place of their "clam-bakes."

MOUSAM, an English local name of the *Maguncook* River.

MUSCONGUS.—No explanation. Conjecture suggests *Moose-kon-koos*, or *mosq*, (a word for *bear*,) *kon-koos.*

NAGUSSET, the name of the point now called *Abagadusset*, (p. 246.)—*Nagusset*, the name of the point in Merrymeeting Bay now called *Abagadusset*, from *naaq*, a *corner*, a point of land.

NARRAGUAGUS.—The Indians do not explain this word. It may come from *nar-ah-e*, before, and *begwatoos*, the last *g* being changed to *t*, and the meaning may be *Before the Bay*, denoting Trafton's Island at its mouth.

NASKEAG, called by Smith[2] Nusket, which is probably a mistake for Nasket, as elsewhere written. As fishing was the employment of the Indians for half the year, it was natural for them to designate the places of their resort with the name of one of the principal means of their livelihood. Hence the frequent use of the word *namas*,[3] in the composition of words. *Naskeag* is abbreviated from *Namaskeag*, or *kik*, and Nasket from *Namasket*, and represents *Fish-Point*, on Blue Hill Bay.

Namasket is also a place on Taunton River, in Massachusetts.

NEDDOCK.[4]—Hubbard gives it as Nidduck, and Jeffreys (Map 51) nearly follows him. It may be allied to *nitauke*, *my place.* In 1654 it was written Nuttake.[5] But a better interpretation has been suggested by the late Judge Potter, from the compound word, cited from Râle, *netegoo'ike*, *clear-land;* and confirmed by a leading Indian of the Penobscot tribe, in the word *nătuah*, an *intervale.* If the name be written *Net-ock*, the meaning, *cleared-land*, well corresponds with this projection, and its back-lying portion, and the many native implements found in cultivation. The Indians here seldom or never named a cape as such.

The large, irregularly shaped rock, separated by a narrow, navigable channel from the point of this cape, was noticed by Gosnold in 1602, when he saw here several Indians possessing articles of European manufacture; such as a Biscay shallop, with mast and sail, an iron grapple, a copper

[1] Letter from Hon. E. M. Hamor, of Mount Desert.
[2] On his map, *Lowmonds*, but in his list *Nusket.*
[3] Also written *namaes*, *namohs*, *namaas*, in different dialects.
[4] So Williamson writes it. Vol. 1, 24.
[5] Hon. E. E. Bourne, Kennebunk, MS. letter.

kettle, clothing of black serge, a hat and band, hose and shoes, blue cloth; and using words that showed that some Basques of St. John de Luz had been in the neighboring waters before him.[1]

NEQUASSET.—Cotton's vocabulary furnishes *nequt-tika* as *eel*. R. Williams supplies *mihtuck-quash-op*, as an *eel-pot*, the first part of the word denoting the wood of which it is made, and the last part its purpose. The similarity of these words to the name of this place may possibly be sufficient to warrant their union with the fact of the abundance of this kind of fish at the falls on this stream, at the head of the tide, and allow the explanation *Eel-Place*.

NEWAGEN.—The name of this cape has been singularly unfortunate in its orthography, appearing as *Anawagen*, *Andawagen*, *Bonawagen*, *Manawagen*, *Nawagen*, *Norwagen*, and *Caphan-of waggan*,[2] and several others. This variety creates a difficulty in the interpretation. Under the word *etroit*, Râle gives *ooskooaighen*. Perhaps the last three syllables enter into this word, which will thus represent the *Narrows* between the southern point of this cape and the adjoining islands. It is mentioned by Levett in his account of his voyage along the coast in 1623, who calls it Cape-manwagan.[3] Williamson says of the northern part, the island of Cape Newagen (now Southport) is separated from Booth-bay, to which it belongs, by a narrow passage for small vessels, called *Townsend Gut*.[4] This description goes far toward warranting the definition of the name here given. Off this cape Josselyn says is the place where Captain Smith fished for whales.[5]

NEW MEADOWS, originally *Stevens' River*, named from a resident on the south side of Merry-meeting Bay, whose house stood near the "carrying-place," about 1640 and later.

OGUNQUIT.—One of the forms of this word, in past days of frequent use, is *Negunquit*, and this suggests that the original was *Oonegunquit*. The word *oonegan* means a *portage*, *carrying-place*, and the termination *quit* denotes locality. The name *Portage-place*, or the *Portage*, conveys a proper designation of a singular ridge of beach-stones thrown up by the action of the ocean near the entrance of a short arm of the sea, to the height of about twenty feet, across which a carriage-road now passes.

OSSIPEE, from *kowâss*, *pines*, and *sēpē* river, *Pine River*, changed from k'wâs by dropping the first two letters.

PASSAQASSAWÂKEAG.—One interpretation of this word is the *Ghost-Place*, or Place of Sights, and the word *negwāssankamawan*, *I see him*,[6] may be cited in its favor. Another explanation takes the word *Passagus*,[7] *sturgeon*, from the St. John's dialect.

PASSAMAQUODDY.—The various orthographies of the name of this bay receive the like interpretation. A Micmac Indian employed by the missionary at Hantsport, Nova Scotia, in translating the gospels, gave the word *Pestumacadie*.[8] Another form is the Etchemin, *Pascatumacadie*.[9] The uniform translation is *Pollock-plenty-place*; or, as given by an Indian chief, *Pollock-catch-'em-good-many*. The abundance of this kind of fish in this bay still continues.

PEMAQUID.—This name of a harbor and river, with the adjoining territory, appears as early as 1607, in the journal of the Popham colony during its continuance at the mouth of the Kennebec. It has been written in many other forms; but all are easily resolvable into this. It is compounded of *pemi*, *crooked* or *winding*, *ahki*, *land*, place, and *it*, a locative; *pem-ahk-it*, representing *At the Crooked River*, and describing the boundaries of the water, in its tidal portion, by the shores rather than the water itself. Its characteristic "crooked" is marked in contrast with the neighboring John's Bay, which goes out straight to the ocean. In pronunciation the sound of *u* or *w* has been introduced for smoothness. It has been given as *Pemacquid*, *Pemakuit*, and by the Penobscot Indians is called *Pemahkwēduc*.

The history of this place can be given only in the merest outline in a brief note, and need not be attempted, as it is to be furnished in an ample volume.[10]

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[1] Archer and Brereton's Relations, 3d ser., Mass. H. Coll., pp. 73, 85, 86.

[2] This last appears in Mason's Will, Williamson; I, 267. Hazard, I, 385, 393.

[3] Me. H. Coll., II, 86.

[4] Hist. Me., I, 55.

[5] Josselyn's Two Voyages, 3d ser., Mass. H. Coll., III, 347.

[6] Râle, "Viser." [7] *Pahsukus*, Barratt'sL ist.

[8] *Pestum*, pollock, *acadie*, place of plenty.

[9] *Pascatum*, pollock. Barratt's pamphlet, taken from Nicola Tenesles. *Pascodum* is given by Sabine.

[10] By Professor John Johnston, LL. D., of the college at Middletown, Connecticut, a native of Pemaquid, now embraced in the town of Bristol.

It may be proper to state that the entrance of this river presented a safe harbor for the many fishermen who were on this coast from Europe as early as 1602, (see Neddock,) and with great frequency afterward. There is great probability that settlements were made here and in its neighborhood before 1620. The late author of the history of Portland considered that the patent granted to John Peirce, in June, 1621, had reference to a settlement made hereabouts, and not to that at Plymouth, for which it has been claimed.[1]

The earliest occupation here, of which no known record exists, appears to have been made on the west side of the inner harbor, on Lewis' Point, where cellars, a paved street, a well, the remains of a tan-yard, and the scoria of a blacksmith's shop have been found; as also the indications of a small fortification and terraced grounds about it. When the place grew in importance and demanded greater protection, the inhabitants appear to have removed to the other side of the bay, nearer the ocean, and placed their habitations and defenses on the high part of the peninsula, now known as Fort Hill; having a commanding position on all sides. Here are found beneath the surface, and at one place on the surface, paved streets, in good preservation, and cellars sufficiently numerous to warrant the tradition of a population at one time amounting to five hundred persons. Articles of various kinds of household implements, and those of the artisan, as well as some for military use, have been here exhumed. The well-protected cemetery has preserved some ancient and quaint inscriptions on the grave-stones, while it is said that many of the most ancient have been thrown over the bank to make room for cultivation.

The wars of the French and Indians against the English required the erection of forts for the security of the residents, which, when one after another was captured and destroyed, were probably placed on the spot where the foundation and part of the wall of the last still remain. The date of the building of the first was in 1630. This was destroyed a few years after by a noted pirate, Dixie Bull, who was in 1631, before he had revealed his character, of so good esteem in England as to be a partner with Ferdinando Gorges, 2d, and several others, in a grant of 12,000 acres of land and more at Agamenticus, (York.[2]) The second fort was erected in 1677, under Governor Andros, and called Fort Charles, and was under the control of the government of New York. It was taken and destroyed, with the neighboring dwellings, by a large body of Penobscot Indians, coming from Castine, in 1689. The next fort, called William Henry, was built in 1692, by Sir William Phips, governor of Massachusetts, to whose authority the right of soil here had previously been ceded. This was captured by the French under Iberville, who planted his mortars on the high grounds on the opposite side of the harbor, and thus compelled a surrender. The last fort was erected by Governor Dunbar, in 1729, called Fort Frederick, and remained till the war of the American Revolution, when it was taken down by a vote of the town, lest it should be occupied by the British to the injury of the cause of liberty. A single farm-house is all the dwelling now remaining, and probably built since the construction of the last fort.

The importance of this place, which bore the name of the "city of Jamestown," may be seen in this extract from an old document in the archives of New York, in which the residents here petition "that Pemaquid may still remain the metropolitan of these parts, because it ever have been so before Boston was settled."

PEMETIQ' the name of a place on Mount Desert.

PENOBSCOT.—The particular locality bearing this name originally has been thought to have denoted the rocky bluff on which the light-house stands at the entrance of Castine Bay, northeast of which is the present township of that name. The meaning is easy to be ascertained, from *penops*, *rock*, and *cot*, one of the locative terminations. The name "Rockland" is a perfect representation of the word, which has been extended by usage to denote a river, bay, county, and town. But a better origin may be found in the word *Pănāwâmpskik*, or, as more closely pronounced by the present Indians, *Pănwâpskĭk*, long used to denote the "Rocky Falls" and the island near by, on which their village is placed, at Oldtown. The change to the now common name of the river is easily accounted for by the usage of the English visitors on the coast. As early as 1607 the narrative of Popham's colony calls it Penobscot, and in 1614 Smith wrote it much in the present form, *Penobskot*, as the name of a place changed by Prince Charles to *Aborden*, which, as placed on his map, appears to be about the position of Castine. The Indians cling to the ancient name and confine its application to the place of the tribal home. They designate the river, not by one name,

[1] Willis' Hist. Portland, Ed. 1865, pp. 22–23.

[2] Records of the Council in New England, March 2, 1631, compared with December 2, 1631.

but by several, descriptive of its several parts, as *Baamtuguaitook*, *Chimsiticook*, *Ahguazedic*, and others.

PISCATAQUA.—This river, the boundary between Maine and New Hampshire, was known to Champlain, in 1605, as *Pescadouet*, not very unlike the name as written by Levett, 1623, *Pascattaway*, and to John Smith, in 1614, as *Passatuquack;* and in later days, as *Pascataquack*, and similar sounding forms, suggesting a combination, under English treatment, of parts of these two early names; and also the probability that, as in other instances, the different localities on the river were known by different distinctive words, according to their characteristics, thus leading strangers to apply sometimes one, and sometimes another, and again intermingling the two.[1] Kancamagus, (*i. e.* John Hawkins,) sachem of the Pennacooks, in writing to Governor Cranfield, in 1685, said that his grandfather had lived "at place called Malamaki (Merrimac) rever, other name chef Natukkog and Panukkog, that one rever great many names."

The first of these names being traced to *pesketegove*,[2] well denotes the *divided* character of the sea-ward portion of this stream, in which unite Spruce Creek, Back River connected with Great Bay, and the Piscasset or Lamprey River. The other name has been derived from *pos* or *pâs*, *great*, *attuck*, *deer*, and *auke*, or *ahki*, *place*, with *w* euphonic, making *Pâs-attuck-wak*, *Big-Deer place;* and probably denoting the territory on the interior portions of this stream. The same words enter into the composition of *Pautuckaway*. In regard to this word, applied to one of the inland ranges of mountains in New Hampshire, it is related that in colonial times, when the inhabitants in that district had become numerous enough to petition for an act of incorporation as a town, they sent by their agents a *large deer*, caught within its proposed limits, as a present to the governor, Benning Wentworth, who thereupon signified his wish that the new town should be called "Deerfield," thus bearing a name indicative of the gift. Henceforth it took the place of *Pautuckaway*, of which it is a good representation.

PRESUMPSCOT.—This word shows how the tendencies of the early settlers led them to make it conform to some better known English word. Here they adopted the idea of the word *presumption*. There are several modes of writing it, and *Pesumpscot* comes the nearest to the true form, which, divided into its parts, presents *Pes*,[3] *much*, *omp*, from *wompi*, *clear*, *shallow*, where the bottom can be *seen*, and *cot*, a locative. The meaning will be *Many-Shallows-River*, corresponding to the many *rips* found in its course, or, as the Indian "sangmau" (governor) at Oldtown explained it, *Rough-places River*

PUMGUSTIC.—The falls at the mouth of the "Wescustogo," or Royal's River, in Yarmouth.

POMKOOSTOOK.—*Mud-stream-place*, from the *mud-flats* just below.

PURPOODUC.—Spring Point on Cape Elizabeth;[4] but was used to denote the neighboring territory. The meaning is not known. It has been thought to refer to a *burying-place*, from the Micmac *Pulpooduck*.

QUOHOG.—A bay, on the shores of which were and are found the round clam, denoted *Poquauhock*, by R. Williams, and Pekwâhak, by Râle. Both these words are in the plural form. See HOG Island.

ROSIER.—A cape so designated from its wild rose-bushes on its rocky shores; from the French.

SÁBINO, also SEBÉNOA, the last two vowels coalescing as in *oak*, and often uniting in Strachey's History, where these names are first found, as in *roap*, *shoare*. The true form would be *Sebéno*. It was the name of a province called by the Indians Sabino, so called of a Sagamo or chief commander under the grand Bassaba. He claimed to be "lord of the river Sachadehoc."[5] The word appears to have a near connection with *sebe*, a river. The explanation by the Indians is, "where a river makes into the land." As a locality it would apply to *Atkins' Bay*, and may be called *The Bay of the River*. The name has been given to a headland near the mouth of the Kennebec. The sachem may have derived it from the place.

SACO.—This name, like Sakunk in the Delaware dialect, from the root *sâk*, outlet, and the locative *o* for *oke*, denotes the mouth of the river. The word by which this river was known to

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[1] Belknap's Hist. N. H., Farmer's Ed., 509.

[2] Trumbull's Ind. Geog. Names, pp. 10, 11.

[3] *Pesangwi, much, Beaucoup*, Râle.

[4] Willis' Hist. Portland, 96, 191.

[5] Strachey's Hist. Trav., Cap. IX, 18; X, 26.

Lescarbot and Biard is *Chouacöet*, (pron. shwâ-co-et,) and probably had a connection with the falls a few miles above its mouth; more names than one not being unusual to mark a stream. The word *m'sooahq*, meaning *dead*, dry, as applied to *wood*, followed by *kooe*, *pine-tree*, and the locative *et*, gives *m'soo-ah-koo-et;* easily changed by the French writers to the word presented above. The pines, once abundant there, may have been burned, like the forests around the *Skootak*, (Fire land Lakes,) and the adjoining territory, thus desolated, may have originated the idea of *The dead-pine-falls.* The oldest reported word of the harder utterance yielded to the easier, and *Saco* now denotes the river, falls, and city.

SAGADAHOC.—This name is thus written in Popham's Latin letter to the King, in 1607. It is derived from *sanktai-i-wi*, to finish, and *onk*, a locative, that is, the *finishing place;* where a river ceases to be a river. It means *the mouth of a river;* but was applied geographically by the Indians to indicate the mouth of the Kennebec, which alone of the large rivers preserves its character of a river till it reaches the ocean. The original form would be *Sank-ta-onk*. Purchas places the name in the mouth. It is written with nearly sixty variations,[1] in some of which the first syllable *sank* is preserved. Near its mouth Popham's colony, in 1607, built their Fort St. George.

SASANOA.—The name of an Indian, who is proved, by a careful examination of Rosier's narrative of Weymouth's voyage to the Kennebec, compared with Strachey's account of the same and of the Popham colony, and with Gorges' "Brief Narration," to have been a chief of distinction, closely related to the Bashaba, whose name, as appears in Strachey and Purchas, was applied to a by-river of some note, meaning the inland passage by water from the Kennebec to the Sheepscot, and by Smith to Agamenticus.

SEBASCODEGAN.—Great island in Harpswell. Among the several variations occurs the early form of *Chebascodiggin*. *K'tche* is *great; t'bascodegan*[2] in Penobscot is a *measure*. This solution of the name shows that the natives had taken some means of *measuring* the island, and had found it *great*.

SEGUIN, in Strachey's account of the Popham colony, is called *Satquin*.[3] Smith says *Sagadahoc* is known by Satquin and four or five isles at its mouth.[4] The meaning is not ascertained. The present name is a Spanish word.

SHEEPSCOT is derived from *seep*, a *bird*, *sis*, *little*, *a* euphonic, and *cot*, a locative. In the Etchemin dialect *seep* is *duck*. *Seepsisacot* is *Little-bird-place*. The well-marked tradition is that the Indians annually, at the proper season, resorted to this river for the purpose of taking the *young ducks*, which were found in great plenty there.

SISQUISIC.—Cousin's River, Yarmouth.

SKILLINGS, from a family of that name.[5]

SMALL POINT.—Levett, 1623, calls it the "Cape of Sagadahoc." On an ancient map, in India ink, of the Kennebec and the adjoining territory, made by John Small, surveyor, it is called by the present name. The "Small" family was resident in the neighborhood for many years, probably at or near "Small Point Harbor." A field-book of another survey of the Kennebec, made about a century ago, is preserved in the library of the Maine Historical Society.

SPURWINK.—A stream in Scarboro', of which the name has some resemblance to an English local name.

ST. GEORGE'S RIVER.—The name St. George was given by Popham to Monhegan; and after this island became known by its original name, it was transferred to the islands and river now thus denoted.

SUSQUESONG.—Cousin's Island, Yarmouth.

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[1] On Johnson's Map of 1754, dedicated to Governor Shirley, this name is given to the *Amorescoggin*, (*Androscoggin*,) as the principal of two alternate names, with the remark that it was "so called by Mr. Pople."[1] Sagadahoc R., so called by Mons. Bellin, and also by most or all the ancient plans "Strachey's account of the Popham colony speaks only of this and Pemaquid Rivers, and mentions Gilbert's going with an expedition for the head of the river Sachadehoc," Chap. X. All the indications of his narrative point to the present Androscoggin, and the name being thus applied in Johnson's Map is confirmatory of the traditional use of this appellation.

[2] In Râle, *Tebakoonigan*, "une mesure."

[3] Me. H. Coll., III, 298.

[4] Mass. H. C., 3d ser., VI, 120.

[5] Willis' Hist. Portland, Index.

Me. Hist. Col., Vol. III, 329, printed Popple. He held an office in the Plantation Office, Whitehall, London.

TOLAM.—The aboriginal name for Falmouth,[1] embracing Portland.

TOWESSIC, and, without the locative, *Towass*,[2] is a point in Woolwich that lies over against the upper end of Arrowsic Island.[3] The Indian explanation refers the meaning to "breaking through." This idea will suit the fact that the by-river of some note called "Sasanoa," in the account of the Popham colony,[4] here passes through a broken place in the high walls of the Kennebec. Perhaps it may be translated "*The Broken Passage.*"

TUNK, applied to a mountain in Hancock County; also to a pond. It appears to be the end of a word, as it is in *Carritunk*. As the mountain is called "Big" and the pond "Great," the Indian name may have been in correspondence with these descriptions; for which *K'tche-t-unk* (Chetunk) will be the appropriate word.

WAUKEAG.—Neck, in Frenchman's Bay. This may have been *Wamkeag*, *i. e.*, *Wamkik*. The name may have been taken from *wampi*,[5] *clear*, *shallow*, (*water*,) and *kik*, a locative, from shallow water near it, and may represent "Shallow Bay."

WANSQUEAK,[6] harbor in Goldsboro'.

WASS is an English surname,[7] now known in the eastern part of the State.

WEBHANNET is the Indian name of the town of Wells; from *web*,[8] a *wife*, *hanne*, a *stream*, and *et*, a locative; and may find its representative in *wife-river*. A similar appliance of this feminine relation may be seen in *Squawagusset*, *Squawhan*, *Squawkeag*.

This explanation is illustrated by the fact that about 1649 Chabinoke devised to John Wadleigh "all his interest in Nampscascoke, being the larger part of Wells, on the condition of the annual allowance of a bushel of corn to the 'Old Webb,' (*i. e.*, wife,) his mother."[9]

WESCUSTOGO.—Royal's River in Yarmouth. The analysis of this word resolves it into *Kowass-koos-togue-oke*, *Pine-stream-trout-place;* all which describe facts once true. The first syllable has been dropped.

WESKEAG is said to mean Grassy River. But if it be an abbreviation for *Kowasskik*, then it will be Pine River; *ko* being dropped.

WHISKEAG, also in a Pejepscot map written *Worsqueage*, suggesting *Kowasskik*, with the same meaning as in the last definition, *k* being lost in English pronunciation. It is a small stream on the west side of the Kennebec, and is regarded as the third of the "runs of water" passed over by Waymouth and his party in his exploration in 1605, and mentioned in Rosier's Narrative as "the farthest and last we passed," which "ran with a great stream able to drive a mill," as it now does. Pines once abounded here.

WINCHEAG BAY, east of Mount Desert, where M. Cadillac lived.[10] *Winne*, *beautiful*, *k'tche*, *great*, *ag* or *ak*, a locative.

WICHACOWICK, the name applied to Ellsworth River and Falls. This word is of the like composition with the others dependent on the *Pines*. In one of the cognate dialects a word is found written *witsh-wock-ak*, explained as *pine-nuts*, which must be the *cones*; *ak* denoting the plural. Thus, this name will be *witsch*, *a* euphonic, *kooé*, or *co*, *pine*, *ick*, locative, *Place of Pine-tree cones*, or, more awkwardly, *Cones of Pine place.*

WISCASSET, called by the Indians *Wichcasset*, has been thought to mean "the confluence of three waters." But there is nothing in the composition of the word to sustain the definition. The same may be said of "the place of springs." Its origin is like that of the last word. *Witschkowass*, plural of *koé*, *et*, locative; Wichkwass-*et*, *Place of Pine-Tree Cones*, or Pine-cones-place.

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[1] J. De Laet, quoted by Williamson, I, 39.

[2] Or *Towess*.

[3] Pejepscot Papers, Vol. I, 121, called *Towasset Bay*, (Back Bay;) Williamson, II, 347, as a boundary of Woolwich. The syllables *et* and *ic* have a similar meaning.

[4] Strachey, Caput X, Sept 27th.

[5] *Umbagog* has a similar origin in *womp-be* from *nebe*, *water*, *g* euphonic, *og* or *ok*, a locative, *i. e.*, *Shallow Lake*, corresponding with the fact.

[6] This may have been *Wompskeag*, with a meaning like the preceding.

[7] Willis' Portland, 321.

[8] Woods' N. E. Prospect.

[9] Folsom's Saco., p. 120.

[10] Williamson, I, 588; note.

APPENDIX No. 15.

CONDENSED ACCOUNT OF M. HELLERT'S EXPLORATIONS ON THE ISTHMUS OF PANAMA, INCLUDING HIS SPECIAL EXPLORATIONS ON THE ISTHMUS OF DARIEN; WITH SUGGESTIONS FOR CONDUCTING A FUTURE SURVEY. BY GEORGE DAVIDSON, ASSISTANT UNITED STATES COAST SURVEY.

GERMANTOWN, PENNSYLVANIA, *March* 28, 1867.

DEAR SIR: Having been at times, during the past year, connected with an organization for exploring the Isthmus of Darien, for a ship-canal, to connect the waters flowing into the Gulf of Darien with the Gulf of San Miguel, my attention was attracted to the several communications addressed by M. Hellert to Humboldt, and to the *Société de Géographié*, published in 1846 in the fifth volume of the Bulletin of that society; and I beg to offer the accompanying condensed information collated from those papers.

A study of Hellert's published explorations in 1844 and 1845 satisfies me that he thoroughly examined the ground, but unfortunately before he reached the upper part of the river Darien or Tuyra, or saw the divide between it and the Atrato, he lost most of his instruments. I judge that he obtained his elevations near that divide by the temperature of boiling water; that he crossed the divide from near Tapanáca; that from his point of crossing and from Paya he noted a marked depression in the divide near the head-waters of the river Paya; and that he reached the Atrato by the Cacarica, which he erronéously calls the river Taréna.

Although the loss of his principal instruments was a sad drawback, yet it must not be overlooked that before this accident he had already examined, crossed, and recrossed several times the isthmus from Veragua to Panama; had familiarized himself with the streams and mountains from Veragua to the Gulf of Darien; had ascended the Chepo, and looked upon the islands of San Blas in the Atlantic from the moderately elevated mountains lying between that bay and the Chepo; had ascended the Chiman, the Congo, Savannas, Marea, Toguti, Pirré, and Chucunaque; measured the distance to which the tidal influence had been felt in each; had measured the altitude of the valley of the Darien opposite Chapigana and at Santa Maria; and from the heights of Mount Paca had looked upon the undulating surface of the *Great Basin of the Darien* and its tributaries. These and numerous other explorations had doubtless familiarized him with relative heights and distances; and with a judgment thus whetted, and keenly alive to the great question at issue, we ought to expect that his compass, thermometers, watch, and aptness at expedients would give some *suggestive* results.

And I am convinced that there is enough shown by his exploration to warrant the use of it as a basis for an exhaustive exploration of this region; especially of the heights lying between the head-waters of the Pucro, the Paya, and the Tapanáca Rivers, and the Atrato or its tributaries.

It is an encouraging feature in his papers that during the months he spent in his Darien exploration he makes no mention of any trouble with the inhabitants, and in fact I cannot see that any need be apprehended when we know that a regular trade by bungoes is kept up between Pinogana, Yavisa, Santa Maria, and the other towns with Panama; that the Indians are engaged in getting out India-rubber on the head-waters near the divide; and that the rubber-seekers of the Atrato are gradually working their way from the left bank of that river up all the small tributaries coming from the Darien heights.

As to the altitude of this divide, I may be allowed to make the following estimate:

From the absence of any figures giving the strength of the current we may assume it as being nothing extraordinary. I take it for granted that it is not stronger than the current of the Chagres, which, for twenty-six miles below Gorgona, falls 35 feet. If we suppose the average width of the Chagres to be 160 feet, and depth 8 feet, with sloping banks, this fall would give a current of about two miles per hour; and my recollection is that it does not average that velocity.

Let us, therefore, assume that from the point where the tide ends in the Darien, six miles above Pinogana, we have a two-mile current all the way to the rapids of Tapanáca, or to the mouth of the

Paya. I think this estimate is large and incline to regard it as only one and one-half miles, because if the current were strong and the descent great, Hellert would hardly propose, as he does, to dam the river in order to make slack-water navigation for the canal itself.

Call the distance to the mouth of the Paya thirty-six miles, and divide it into three lengths of twelve miles each; call the width of the lower part 200 feet; depth, 8 feet; cross-section, 1,472 square feet, &c., &c.; and the current two miles per hour, then the rise per mile would be 0.8 foot, or equal to 9.6 feet for twelve miles.

Call the second part 150 feet wide, 8 feet deep, 1,072 square feet cross-section, &c., and the current two miles per hour; then the rise per mile would be 0.85 feet, or equal to 10.2 feet for twelve miles.

Call the third part 100 feet wide; depth, 7 feet; area of cross-section, 602 square feet, &c., with a current of two miles per hour, then the rise per mile would be 1.25 feet, or equal to 15 feet for twelve miles.

For the four miles to the falls estimate the rise at 2 feet per mile, or 8 feet for the four miles.

These sums would give 43 feet rise to the Tapanáca Falls.

From his position at Tapanáca, (I assume at the falls,) Hellert gives 160 feet as the elevation of the culminating crest of the divide above the waters of the Darien in its highest part; this would give the crest an elevation of 203 feet above the tide at Pinogana.

If he obtained this height by the experiment of boiling water, we may readily assume that he made an absolute error of 0.1 degree Fahrenheit in the difference of the two temperatures; this would give an error of 51 feet in his determination of the difference of elevation, and suppose we *add* this error to 203 feet, we have 254 feet as the highest point where he crossed.

On the other hand, it is to be remembered that he saw a "very sensible depression" north of where he crossed, and also a "sensible depression" from Paya; now let this sensible depression be 54 feet below his crossing point, and we have an elevation of 200 feet for the divide of the Darien, or Tuyra, and the Atrato, above the tidal waters of the Darien.

Very truly and respectfully yours,

GEORGE DAVIDSON,
Assistant United States Coast Survey.

Professor BENJAMIN PEIRCE,
Superintendent United States Coast Survey, Washington, D. C.

EXPLORATIONS.

In 1844, M. Hellert explored the province of Veragua, "walking in a zigzag direction from the Pacific to the Atlantic, alternately passing and repassing the great Cordilleras from the frontiers of Costa Rica to Panama; taking the latitude and longitude, in this five months' trip, of the principal points, and especially determining the heights and positions of mountains, the courses of rivers, and their practicability for an interoceanic canal."

He had already examined the districts of Chorera, Los Santos, Nato, and Paretu, in the west and southwest of Panama, and has given the average elevation of the plains in the region of Nato, Penonomé, and Santa Maria, as well as some of the noted mountains.

Up to this point of his explorations he expresses the opinion that the route that has the best show of success is from the bay of Montijo by the San Pedro River to its sources, which are only four leagues from the source of the Conaberal, which falls into the Atlantic. But the dividing ridge is 700 feet above its base, and the northern slope very steep.

The broad conclusion to which he arrives is, that in the province of Veragua there is no practicable route for a canal; and the same may be said of Panama.

Disappointed thus far, he acted upon the advice or suggestion of Humboldt in 1802, that a thorough exploration of the isthmus of Darien would doubtless be rich in geographical results.

In 1845 he started eastward from Panama, and determined the elevation of the longitudinal plateau from Panama to the Chiman, from which to carry his explorations and especially his elevations to the Chepo and Chiman.

He ascended the Payal from the district of Chepo. I understand this stream to be the Chepo itself, because he says, "The Payal from fall to fall pours its muddy waters into the flat, sandy beach of Mariprieta, opposite the small island of Chepillo." Again, he says, "I ascended the Payal for eight leagues, but an insurmountable fall stopped me." Later in the season he ascended the flattened summit of Mount Chipo, (of medium elevation,) extending to the north and to the south and eastward, whence he could see the isles of San Blas. He moreover adds to his observations that the channels of the Chepo, &c., are not sufficient to permit a water-way.

The area drained by the Chepo and its tributaries is about 1,200 square miles, bounded by the Chiman Range on the south, and by the mountains of San Blas (or Chepo) on the north. He then tried the Chiman, but was unsuccessful in finding any available route for a canal.

The longitudinal plateau on Panama Bay, and lying between the Chepo and Chiman, he places at an elevation of 126 feet above the sea.

He next tried the Congo, emptying into the northwest part of the Gulf of San Miguel, and failed.

From the pueblo of Garachine, in the extreme southern and western part of the Gulf of San Miguel, he recommenced his labors with an examination of the gulf itself; ascended the rivers Savannas, the Marea, the Toguti or Balsas, the Darien or Tuyra, the Chucunaque, the Pirré, the Yapes, the Pucro, and the Tugra, and Cana beyond the Tapanáca Rapids.

He establishes the mouth of the Darien or Tuyra at Bocas Chica and Grande, and says that from elevations of 200 to 250 feet, and distant half a league, the immense valley opens to the north-northeast, to the east, and to the southeast, much depressed, and that in this valley runs the Darien and its tributaries.

To take in the general topography of this great basin of Darien he ascended the heights of Mount Puca or Paca, and saw "a river whose waters are like those of the Mississippi, much higher than the land which incloses them on the east." It is curious that from his point of observation he does not appear to have seen the depression in the Espiritu Santo Mountains at the head-waters of the Pucro, Paya, and Tuyra.

This great basin is bounded on the northwest by the mountain range Chiman; on the north and northeast by the mountains of Tuquera; southeast by the mountains of Espiritu Santo, and south by the lateral spur from the latter, embracing Mounts Para and Zapa, whence rise the Pirré, Toguti, and Marea.

We estimate this basin to embrace over 3,600 square miles.

The vast amount of water brought down by the Darien and its affluents in the dry season is referred to several times as likewise indicating the extent of the great basin.

This astonishing volume of water also indicates in a marked manner the *lowness* of the upper parts of the different valleys of this basin, and points to the existence of marshy ground. We cannot estimate the volume, because no data are given of the strength of the current or the area of the cross-section.

In his explorations, M. Hellert ascended the Savannas, and found the tidal influence extending more than five leagues up the river; in the smaller rivers Marea and Toguti, it ascends from two to five leagues; and in the Chucunaque, seven leagues higher than the village of Yavisa. The distance of tidal influence is not given for the Pirré; but his description is interesting and important, and is here introduced:

"The river Pirré empties into the Darien, at the village of Real de Santa Maria; it is 600 feet wide at its mouth, and carries this width for more than two miles. In ascending, its depth at low tide is between 18 and 15 feet. This village so favorably situated at the angle of two large and deep streams, and on the slope of Mount Pirré, may become a depot," &c. The plain toward Mount Pirré is represented as of the highest fertility, and the region full of fine timber, from which the largest canoes are made. Some of the "Bungoes," more than 75 feet long and 6½ feet wide, were cut from single trees.

We may conclude that in the river Pirré the tidal influence is felt for at least three leagues.

Up the Darien or Tuyra the tide ascends two leagues above the town of Pinogana, or four and one-half leagues above the mouth of the Chucunaque.

This inland influence of the tide in the Darien and its tributaries reveals the nature of the extraordinary depression of the great basin and its deep inclosure in a deposit composed of recent formation.

The Upper Darien, reckoning as such the main stream above the Chucunaque, is fed by a great number of rivulets, often very deep, taking their rise in three *ranges* of mountains, named the Cerro de Pirré, Paca, and Espiritu Santo. It is evident that he here includes the "Altas de Pucro," lying between the northern extremity of the "Montanas del Espiritu Santo," and the southern extremity of the mountains of Tuquesa. The names of the principal tributaries of the Upper Darien are given as follows: the Piré, the Tuña, Cochina, Uruti, Tumbisava and its tributaries, Hyati, Anisa, Lepé, Cupé, Citum, Spalisa, Piedras, Paca, Cruz, Limon, Paya, Cana, &c., &c. And the aggregate volume of water contributed by these streams is equal, if it does not exceed, that of the four larger rivers of the Lower Darien.

This amount of water supply is evidently based upon no calculation, because the area of country drained would indicate it as too great, unless the rain-fall in the nearer region to the Atrato is much greater than toward the northwest, and we know that the rain-fall in the Atrato Valley is enormous.

The Yapes, where M. Hellert lost most of his instruments by the capsizing of a canoe, he describes as a rapid tributary of the Upper Darien, above the town of Molineca. The Pucro, the Darien or Tuyra above the Tapanáca Rapids, and the Cana, which he ascended, are not described.

We may well believe his assertion, however, in regard to explorations of several months in Darien, that "there are few rivers which he has not ascended as high as possible."

Commencing at the head-waters of the Darien, he gives the following general remarks on its course. Rising in the mountains of Espiritu and taking the name of Tuyra, its first general direction is to the north one-fourth east. After receiving the Sedeganti and Cana, its course to the rapids of Tapanáca is north-northeast, then north-northwest to the Pucro; then abruptly west for 8 or 9 leagues; thence west northwest to the Gulf of San Miguel. Its upper part, from the Pucro to its source, may be estimated at 26 to 30 leagues, which will give a total of 49 or 55 leagues for its length.

Following the Darien from its mouths, Bocas Chica and Grande, he describes it as follows:

From Boca Chica to the village of Chapigana, 11 miles, a small chain of hillocks, about 100 feet high, borders the river at a distance of 1¼ miles. Opposite and nearly east of Chapigana the banks are low, and the valley "en face" of Chapigana he estimated from observation to be 45 feet above the level of the sea. From the river Marea to Islas los Lagartos, the left bank is very low, and in several places periodically submerged. A great part of the banks of the Lower Darien may be said to be covered with mangroves, and periodically submerged. From Santa Maria, at the mouth of the Pirré, to the rapids of Tapanáca, the banks are from 30 to 80 feet high, sometimes more, rarely or never less, their slope more or less abrupt, and they perfectly shelter from inundations the upper region bordering on the Darien. In fact he declares, in another connection, that good roads for tracking can be built on the banks of the upper river.

The valley of the Darien, in the vicinity of Santa Maria, he estimated from observation to be 158 feet above the sea, and he used that as a base for his subsequent observations. The general incline of the banks of the river is from east to west, with the longitudinal course of the valley.

The Upper Darien he could not study so well on account of the loss of his principal instruments, and because of the difficulty of penetrating the *marshes*, and having to swim a large number of streams.

From Boca Chica to Molineca, four miles above the mouth of the Chucunaque, the depth of the river decreases, with few exceptions, regularly from 44 to 13 feet. From 6 miles above Pinogana, where the tide ceases to flow, (and 13 miles above Santa Maria,) to the rapids of Tapanáca or Pelisa, the depth of the river in the dry season is never less than from 8½ to 10½ feet. In the wet season the level of the water is from 5¼ feet to 11½ feet, and occasionally as much as 16½ feet higher than in the dry season, according to localities.

In a subsequent paper he says the depth of the Darien in the dry season, from Santa Maria, at the mouth of the Pirré, near Chucunaque, ranges from 4 meters (=13 feet) to 2 meters, (=6½ feet,) and that during the wet season it often rises to 8 meters, (25 feet,) but oftener to 5 meters, (16½ feet.)

The wet season he mentions elsewhere as July, August, September, October, and November.

The Darien flows generally over a bottom of sandy mud, coarse sand, and small stones. No rock is indicated in its whole course from its mouth to a little below the rapids of Tapanáca; and in no part of M. Hellert's various papers do we find the least intimation of any rapids on the river. This is consistent with his general project for the course of a canal, wherein he proposes to use the *Upper Darien itself*, from the rapids of Tapanáca downward, or by the *Paya and Darien;* and he thinks that in only thirteen to fifteen places would it be necessary to dredge below the falls to get the adequate depth of water for large vessels.

The heights which separate the basin of the Darien from the valley of the Atrato begin not far from the village of Pucro, which, on a map of 1851, is placed 10 miles above the mouth of the Pucro and 3 miles above its confluence with the Topaliza.

Standing on the heights of Pucro, (480 feet,) the depression between the mountains of Tuquesa on the north, and the mountains of Espiritu Santo on the southeast, is very marked, no longer partaking of the nature of mountain but of "heights;" while "the immense valley is easily seen through which these two great rivers (Darien and Atrato) flow at such a small distance from each other." The distance which separates the Upper Darien from the Lower Atrato may be traveled in six hours, but the foot-traveler is obliged to make many windings in this wooded country. It is probable that an exact study of the ground would develop a more direct road, and reduce the distance to not much over 10 miles.

From this point—Pucro—at a slight elevation are distinctly seen the fires burning in the southwest in the village of Para, on the Darien; in the south those of Tapanáca, near the rapids; and in the east one-fourth south, the valley of the Atrato.

The heights separating the valley of the Darien and the Atrato, begin, as before stated, not far from Pucro, pass between the Cacarica,[1] a tributary of the Atrato, and the rapids of Tapanáca or Pelisa, and lose themselves beyond the ancient gold mines of Cana, (a tributary of the Darien,) in one of the lateral spurs of the mountains of Choco, in which rise the Pirré, Toguti, and Marea.

In this depression, nearly four leagues long, the heights rise only 170 feet above their base. But at one place in this divide, to the *north* of the point,[2] where he passes from one river to the other, (Darien to Atrato,) there is quite a sensible depression in the chain of hillocks, but the guides refused to follow this line, pretending they did not know the road. He adds "that if this depression is very great it may be of much assistance for further study, although by it the distance may be further from the Darien to the Lower Atrato, by a mile or two."

"The culminating crest of this chain of hills, which on the east border the Darien and separate it from the valley of the Atrato, has an altitude of nearly 160 feet above the level of the waters of the Darien in its most elevated part, one mile distant on the right of the rapids of Tapanáca." At two miles to the north of this culminating point, the ground gradually slopes over an extent of 13 miles; then it becomes an almost horizontal plain over an extent of 7½ miles to the shores of the Atrato.

But if the Darien is descended from the rapids of Tapanáca to the village of Paya, nearly 7½ miles lower down, a very sensible depression is noticed in the dividing ridge, of which a distinct view is obtained from the heights of Pucro. "If this depression offers the facilities I suppose it does, there is no doubt that the canal ought to start from Paya, and not from Tapanáca."

Concerning the geological formation of this ridge, we derive no information from M. Hellert's reports. He says, "The heights which separate the Darien from the Atrato are all composed of the *débris* of surrounding lands, and rest everywhere upon beds of clay and marl." The ground is composed of recent alluvium, and no rock is indicated in the banks or bottom of the river except a little below the rapids of the Tapanáca. What are the characteristics of the rapids or falls of the Tapanáca are nowhere mentioned; whether an absolute fall over a rocky wall, or of the nature of rapids over a steep rocky bottom.

Of the banks of the Atrato he declares that he has not seen the immense marsh between the

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[1] Hellert always speaks of this stream as the Taréna, which is really not a tributary of that stream. That the Cacarica is here intended is proved from the fact that in his estimate of distances for the canal, &c., he places the mouth of this stream 22½ miles from the *Taréna mouth* of the Atrato, while on the Admiralty Charts the distance is laid down as 25 miles.

[2] Hellert probably passed the divide from near the rapids of Tapanáca, or the village of Tapanáca, to the Cacarica.

divide and the mouth of the Atrato as laid down on most maps. Its shores are really very low, but notwithstanding the extraordinary drought which prevailed in 1845 over all the coast from the Gulf of Maracaibo to Cape Tiburon, he cannot admit that such a marsh could become dry in the course of a year, as he appears to have found it.

His conclusion is from a concurrence of natural facilities and knowledge of the difficulties attending other isthmus canal projects, that the Isthmus of Darien is the only one by which any canal project can succeed promptly and at limited expense. He denominates it the real key to the Pacific.

M. Hellert frequently refers to his chart as presented to the Society of Geography for their examination; but it is not published with the proceedings.

Of the climate on the Darien, and of this great transverse break, he says: "The east winds blow from 6 a. m. to 7 p. m. During the night the westerly wind prevails, and in the rainy season the wind is from north and northwest."

A short but instructive table is given of the mean observed temperature taken at from 2.6 to 3.0 feet below the surface of the soil, and in the shade, on the Isthmus of Panama, and in the Darien, in 1844 and 1845. His hygrometric observations show that he was at Santa Maria in March, 1845; Pinogana, in April, 1845; Yavisa, in May, 1845; Marea, in June, 1845; and Chapigana, from July 1 to July 8.

ISTHMUS OF PANAMA.

		Fahr.
1844.	At Chagres	82.2
	Panama	84.6
	Chorera	79.5
	Penonomé	79.0
1845.	Portobello	81.7

ISTHMUS OF DARIEN.

		Fahr.
1844.	At Isla Iguana	78.3
	Chapigana	79.2
	Santa Maria	77.5
	Molineca	77.9
1845.	Cana	75.4
	Atrato	78.4

PLAN FOR EXPLORATION OF THE RIVER DARIEN, ETC.

I suppose the party to be limited to the smallest number that can produce results combined with accuracy, and give mutual protection; and that a Government vessel carries it to the Gulf of San Miguel, and as far up the river as Chapigana, whence it may be forwarded in launches to Pinogana, 20 miles higher up. This party should be composed of a chief engineer and three assistant engineers, with probably two officers volunteering from the ship.

The chief engineer should control the organization of the party and the plan of work under general instructions, limiting the area of exploration. When the details of the survey have been commenced he will pass into the country to study the general topography of the section embracing the problem at issue. I suppose that he can start on this exploration with an officer from the ship, one of the handiest men of the ship as cook, and an interpreter, besides the canoe-men.

The first, second, and third assistant engineers are to have each a canoe, with three canoe-men in each; a handy man for general assistance from the vessel, and an interpreter; the first assistant to have charge of the surveying details, under directions of the chief, and to make all the observations with the gradienter for level, courses, distances, and altitudes. The man with him should be able to record the observations, and to regularly duplicate them each night. A regular cook should accompany this party.

I would start the party with forty days' navy rations, with but few luxuries, and the simplest outfit for cooking, &c. Or if rations could be sent after the party and overtake them, it should start with twenty days' rations and have twenty or thirty more to follow.

Two tent-flies might be carried, but the canoe-men make necessary shelter for the night from leaves, &c.

An officer from the ship should have charge of a heliotrope on the heights of Pirré or Paca, to give and receive signals, if practicable; to observe the azimuths of signals, &c.; and to direct at Pinogana or Santa Maria a full series of tidal observations.

Two plans of general operation are open for prosecution. To ascend the Darien River at once

with the whole party to the divide, discover the depression, and work either to the Atrato or down the Darien. With a vessel on each side, this has the advantage of always approaching the sources of assistance, and the engineers being in good health can be engaged in exploring for the depression. It has the great disadvantage of commencing an important investigation without experience in a country where this, and a knowledge of the native character, are of the greatest importance.

Operations should commence from Pinogana, where the river is supposed to be about 100 yards wide, with a depth of 8 or 10 feet. This town has bungoes trading to Panama, and part of the country in the vicinity is used for raising stock. An interpreter can doubtless be obtained here, and canoes and canoe-men. Canoes rate at about 80 cents (silver) per day, (locally known as a "soft dollar,") and canoe-men at the same per head, although their usual rates are barely half these prices. Much more work can be gotten from the natives by a judicious use of presents.

While the arrangements for ascending the river are being made, the observations to be hereafter detailed should be made at Pinogana, and an examination of the whole basin of the Darien made from the heights of Paca or Pirré. I consider it very important to make this attempt because this mountain (or mountains) as laid down on the maps is nearly on the prolongation of the Pucro, Paya, and Tapanáca, and possibly the great depression at their headwaters may be visible. If it is, I would open space enough on the eastern side of any height in the vicinity to show signals by heliotrope or fire, toward the depression; and would run a line of levels, courses, and distances to the bench at Pinogana so that zenith distances observed from the divide would be of service. It may be very useful and important to communicate information either way by heliotrope flashes; for this purpose a system similar to that which I devised in 1851 for differences of longitude may be used. Appendix B will explain the manner of using signals. The Davidson heliotrope, weighing six to ten pounds, can be easily used for this work.

Pending the arrangements for starting, I would determine the latitude and longitude (by chronometer) of Pinogana, with observations for azimuth and variation.

The six-inch Gambey vertical circle is preferable to less accurate but more portable instruments, because it has good illumination for night observations if necessary, is better graduated, and admits of repetitions by double-zenith distances directly and by reflexion. It is also easily and rapidly manipulated.

For latitude, by night, observe at least two sets of six repetitions, each of double-zenith distances, on a north star near culmination, and the same upon one or more south stars, noting the times by the chronometer, recording position of the circle, the temperature, and the barometer.

If night observations are impracticable, then observe double-zenith distances of the sun, on both limbs, before and after meridian, directly, and, if practicable, by reflexion; six repetitions can easily be made in eight minutes per set, including the reading of the verniers and levels.

For time, observe double-zenith distances of two stars nearly east and west; two sets of six repetitions each on each star, noting times, levels, barometer, thermometer, face of circle, &c.

If night observations are impracticable, observe upon the sun's upper and lower limbs, when not less than 20° high; two sets of six repetitions should be observed upon each limb. Reverse the face of the instrument.

Observe for time whenever opportunity permits. If practicable, determine the temperature of the earth three feet below the surface and in the shade; repeat this experiment at the divide and other points.

All the observations by day may be made between 8.00 a. m. and 0.30 p. m., or between 11.30 a. m. and 4.00 p. m.

If it is at all feasible to carry the vertical circle over the whole route, it will add vastly to the value of the results, and to our geographical knowledge. It certainly can be taken by canoe to Pucro, Paya, Tapanáca, and intermediate points. It would be of great importance at the mouth of the Cacarica to determine the latitude at least.

Tidal observations should be established at Pinogana upon first reaching there; the readings of the tide-gauge should be referred to a bench-mark, and this in turn should be referred to the point where latitude and other observations are made.

For the instrumental outfit of the chief engineer and assistants see Appendix A.

Leaving the surveying party, composed of the first, second, and third assistant engineers, to continue the work up the Darien, as detailed hereafter, the chief engineer should ascend the river, making every exertion to obtain a view of the divide and of the depression noticed by Hellert in that divide; ascend the Pucro to the Pucro village, and, from the heights near it, ascertain the general position of the divide, and determine its direction; also whether the natives had any regular trail from Pucro across it to the Atrato; observe for latitude and longitude and make observations for altitude and bearings of all well-marked objects, especially of such as might be observed upon by the surveying party. Mounts Pirré and Paca should be particularly observed upon, and some mountains to the southward in the vicinity of Cana. From the position occupied, ascertain by hand-level and aneroid the height above the Pucro. Hellert says that from this vicinity he saw the fires of Para on the Darien burning in the southwest; in the south those of Tapanáca near the rapids; and in the east one-fourth south, the valley of the Atrato; while the whole basin of the Darien lay at his feet.

Ascend the Darien to the rapids of Tapanáca, and the Indian village of Tapanáca, on the Tapanáca, which rises in the divide, according to the maps. Hellert says that the culminating crest of the divide has an altitude of nearly 160 feet above the level of the waters of the Darien in its most elevated part, one mile distant on the right of the Tapanáca Rapids, and that from this coast he saw a "sensible depression" to the northward. This depression he also saw from Paya Village, which he places nearly opposite the mouth of the Paya. Measure the height of this culminating crest above the Darien by hand-level and aneroid, and, if possible, determine its latitude, and observe upon all marked objects and the smoke from any villages. The approximate position of the "sensible depression" may be determined from here.

Descending the Darien to the mouth of the Paya, go up the Paya as far eastwardly as it runs, and at the village near the divide procure guides, if necessary, to cross the divide by the regular trail used by them; determining, with hand-level and aneroid, the summit of the divide, and the depression of the point where the Cacarica or either of its tributaries is struck.

If it is not practicable to obtain guides who know and can point out the greatest depression in the divide, and if the previous evidence from points on the river, from Pucro and from Tapanáca, still points to this locality, the judgment of the chief will have to devise means of finding it through an almost impenetrable forest.

If the divide is generally flat-topped, I take it for granted that wet ground will exist at the flattest or at the lowest point, and that the drainage from it will in a measure afford some indications. Moreover, the natives would not cross regularly at a part subject to overflow, but where they would have a fair path even in the wet season.

My impression is, that with a good number of judicious presents much can be learned and accomplished; but not hurriedly in this "pocopoco" country. Kindness will do much; force and bad temper, nothing. Even if the natives refuse to communicate any knowledge of the divide, it may be practicable to ascertain from some elevated point, or from some high tree, very nearly its position.

In the mean time, preparations should be under way for getting two or three canoes upon the Cacarica by carrying them across or by building.

If the depression lies between the head-waters of the Paya and Cacarica, as Hellert believed, I think its general position will be reduced to narrow limits, from the preliminary observations. If it is necessary to wait for the arrival of the surveying party to make a detailed and exhaustive search, I would carry the regular work up the Paya, and all its tributaries coming from the eastward, as far as deemed necessary, and leave benches *en route*. Descend the Paya to the trail over the divide and run courses, distances, and levels over it, or on a line opened for the purpose to the Cacarica, and carry the regular survey, to the northward, up that stream or its tributary, and up every tributary coming from the westward. This work would exhibit the approach or divergence of these streams, the rate of increase of elevation, and its relation to the levels over the trail. From this a better judgment can be formed of the locality to be examined specially. The same system of exploration should be made near any indicated depression.

But at this stage of the expedition the determinations of the chief engineer and of the sur-

veying party will have sufficiently developed the position of the greatest depression in the divide, and so will limit the final exploration to within comparatively narrow bounds.

Across the divide run a line of levels, courses, and distances to the stream flowing to the Atrato, and down that stream, as indicated in the duties of the first assistant engineer.

In this general plan it is supposed that a United States vessel is lying on each side of the isthmus to assist the party, and aid, if needful, in the actual exploration. The vessel on the Gulf of Darien might make an examination of the mouths of the Atrato, and send a party to the mouth of the Cacarica, 25 miles from the mouth of the Caño Taréna, to determine its position, and possibly to ascend the Cacarica.

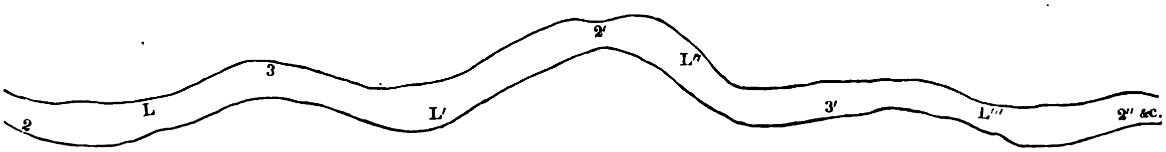
The vessel in the Darien River could make a thorough examination of the Darien from Boca Chica, or from Savannas River, to Pinogana; and if this was not completed it could be finished by the surveying party upon its return from the divide. In this survey it would be advisable to ascend and survey the Pirré River, as Hellert's notes indicate it as a valuable stream on account of its depth and width.

Hourly barometric observations should be made on the vessels from 5 a. m. until 7 p. m., and the amount and time of rain-fall should receive special attention.

OUTFIT AND DUTIES OF THE FIRST ASSISTANT ENGINEER.

Gradienter.—Start from Pinogana with levels referred to bench-mark of the tidal observations. Select a position as far in advance as practicable, choosing one that combines most advantages for leveling, for distances and courses, and for the determination of outside objects of topographical interest, and to check the work. For these purposes it is desirable to occupy both sides of the river alternately, or the reaches of the river, in such a manner as to obtain views to the northward and southward, especially at the outset.

The plan of a day's work would be something in this order:



L, L′, L″, &c., represent the successive positions of the first engineer with the gradienter, which, instead of spider lines liable to destruction in a drenching, should have marks ruled on parallel plain glass and secured to the diaphragm so as to admit of the usual adjustments; 2, 2′, 2″, &c., those of the second engineer, with one of the leveling and distance rods; 3, 3′, 3″, those of the third engineer, with the second leveling and distance rod. No. 2 is the position of the back rod at the start; L, that of the gradienter; and 3, that of the fore rod, selected by himself to see L and the next anticipated position of the instrument at L′. L observes upon 2 for level, course, and distance, and signals that he can go forward to choose a position (2′) for himself that will see the two anticipated stations L′ and L″. Then L observes upon No. 3 and signals him to that effect, leaving him to make any examinations of the stream or other duties detailed; and after making any extra observations, L moves to L′ at once, observes upon No. 3, and signals him to remove to a position (3′) beyond 2′ that will permit observations from the yet unselected station L″. This system of progress is available for going down as well as ascending a river.

Probably three miles per day can be made in this manner. The records should be duplicated every night; if practicable, the courses and distances should be plotted to allow any directions made upon the divide to be fixed. The note-book ruled in squares throughout, so that the scale may be one inch to a mile, should show the general plan of the river, features of bank, &c.

From the starting-point, and from every available position that will see the greatest number of natural objects, observe the bearings of any two well-marked and readily distinguished mountains, situated to the east-northeast, and also the peaks of Pirré and Paca to the southward. The positions of these mountains will, in the earlier part of the work, become well enough determined to serve as points upon which bearings can be taken from the higher reaches of the river, and thus

aid in testing the courses and distances, and in some degree the elevations, especially in the event of the gradienter being lost and recourse had to less reliable methods. Mounts Pirré and Paca would appear to be well situated for this purpose; they lie southward of Pinogana ten or fifteen miles, according to different authorities. None of the maps indicate isolated peaks to the eastward, yet some marked object will doubtless present itself to the observer.

Observe vertical angles with the gradienter upon all objects, as adding to our geographical knowledge as well as verifying that already acquired.

Hellert says that from the heights of Paca he was able to overlook the great basin of the Darien; and from the peculiar position of this mountain on the prolongation of the valleys of the Pucro, Paya, and Tapanáca, it may be very desirable to open a view to the eastward upon some one of these heights that will permit observations toward those streams and the divide, and admit of vertical and horizontal angles being measured to test the altitudes, courses, and distances, and for communicating signals by heliotrope between observers on these heights and others on the divide. If its position is determined before the exploration starts up the river, the observer on the divide may with certainty direct his heliotrope to the Paca station. A system of heliotrope signals is described in Appendix B.

When on that part of the river running generally north-northwest and south-southeast, commencing a few miles below Pinogana, every opportunity should be seized of bluff bank, hillock, and reach of the river to look for the depression which will lie between east and southeast. Consult Hellert for the extent of this general depression and for the break or breaks which he saw in it.

Observations of this kind upon the divide will limit the extent of the exploration and possibly fix the position of the lowest point in it. Always observe the angle of elevation of the lowest part of this divide, stating in the notes whether the view is clear, &c. Note also the time and state of the barometer and thermometer.

The record of the readings upon the leveling rod made by the observer himself, and of the distance wires and horizontal circle, will be entered according to the annexed form, Appendix C.

The opposite page of the record should be used for vertical angles and every particular relating to the operations; nothing whatever should be left to memory, and too many notes cannot be given.

Each day, when the labors are closed, drive a stake in the border of the stream near the encampment, make a notch on the stake to mark the surface of the water, and note the time and weather; when leaving next day measure the rise or fall from the mark, and state time, weather, &c. Note particularly the rain-fall in any available vessel set out during the stay for the purpose. If the tin pan, kettle, or pot should not be cylindrical and flat-bottomed, state dimensions.

Make a recognizable bench-mark each night upon some prominent tree.

Each morning and night make special examinations for the *mean velocity* of the stream by floats, and its width and cross-section by actual measurement and sufficiently numerous soundings with the sounding-rod. Appendix G gives some of the details of the operation, with formulæ for deducing results, if desired in the field.

Determine the position of the mouths of all tributaries, and whenever practicable their size, &c. Note the names given by the natives.

This system of observation will be carried up the stream or its tributaries as indicated by the results of the exploration of the chief engineer, and this survey, to the point or points where the divide is to be crossed. Although regular paths exist across this divide and are regularly used by the inhabitants of Pucro, Paya, and Tapanáca, yet it is more than likely that lines will have to be opened; for this purpose, as well as for clearing, for encampment, and shelter, the canoe-men should carry machetes with them.

Where the stream or streams are left in order to cross the divide, a bench-mark specially indicated should be made, and also a secret mark upon some easily recognized object. The same should be done at the summit, and on the northern and eastern sides of the divide when reaching any of the tributaries of the Atrato. From these points observe, if practicable, upon all the mountains in view, and on the smoke of villages, &c.

In descending the tributary toward the Atrato, I presume it practicable to work with three

canoes as in ascending the Darien, in which case the same system of river-work will be carried out. Should only two canoes be available, the system of back and fore sights should be persisted in, and the operation of leveling, &c., will be exactly similar to that on land. This system of levels should be carried to the swamp-waters of the Cacarica or Atrato; but the courses and distances through to the Atrato, where the latitude should be determined.

The maps indicate that the Cacarica, or some large tributary of the Atrato, empties into the Atrato, in latitude 7° 57½′, after coming twenty or thirty miles from the southward, along the east base of the mountains of Espiritu Santo and the divide, converging slightly from parallelism with the Atrato, and that in its course it swells into several small lakes and ponds. Hellert says, there is no marsh between the divide and the Atrato, but the above formation given in Trautwine's map, and the existence of swamp mentioned in his notes, would indicate much overflowed land even at the dry season. At the wet season I deem it next to impracticable to follow this stream through the marsh, but would run for the Atrato by compass.

In the dry season, even without guides, it is deemed practicable to follow the Cacarica, though every lakelet might make it necessary to search its borders for the outlet. When making such an examination, leave a well-blazed tree and a large white muslin signal nailed to the tree where the stream enters the lake, as a mark for returning as well as for observation in course and distance; and so for the outlet of each lake. A piece of white muslin of given length serves not only for courses as a mere signal, but for obtaining the distance across, by the wires of the gradienter, and leaves the canoes free to search for the outlet. The work thus progresses rapidly.

If all the signals thus set up are destroyed before returning, the courses and distances and blazed trees will mark the track.

The *steel barometer* (Würdemann's) should be read every morning before starting, and the aneroids of the assistants should be compared and noted; also at night as soon as practicable after closing operations. The height with reference to the bench-mark should be noted. Practice with this barometer should be acquired before starting, by several times filling it to give facility and knowledge in manipulation. An extra glass cylinder should be carried lest the one in the barometer be broken; and an extra steel cap to cover the top of the mercury column should be supplied. One pound of mercury is sufficient. Instructions for the use of the steel barometer are given in Appendix F.

Aneroids must be taken that are the least liable to derangement from jars; the coefficient of temperature should be carefully determined, and the instrument afterward tested for altitudes over a railroad with large, well-known grade. Of course, the barometer observations are not strictly to be relied upon; but they afford opportunity to test the value of their results in such undertakings.

Appendix E gives the correction for horary changes of the barometer, as deduced from the Girard College observations.

At night the observations of the first engineer should be duplicated, copies placed in charge of the second assistant to provide against the loss of originals, and a general comparison of the day's work should be promptly made.

OUTFIT AND DUTIES OF THE SECOND AND THIRD ASSISTANT ENGINEERS.

For outfit of instruments see Appendix A.

In running the levels up or down the rivers the general plan of selecting stations, &c., is detailed under the duties of the first engineer, and need not be here repeated.

As soon as the second or third engineer has selected the position for his rod, and before the first engineer is ready to observe, he should make some soundings across the stream sufficiently numerous to get the accurate cross-section of the river. Also find the width of the river by a line immediately afterward measured with the tape line held in reserve for such purposes. If practicable, let the staff section be selected near and above the mouth of a stream; and particularly note the streams passed, their size, if practicable, and general appearance of current, &c. Get the cross-section of the tributary near which the staff is placed.

When placing the leveling-rod in position drive a short stub into the ground, and place the foot of the rod upon it so that in turning round to face the back observation no change in height

will take place. If the station must be in the water, drive in a stake so that the top will be near or at the surface, and note the conditions and its distance from the bank, the height of the bank, &c. If the staff must necessarily be in deep water, note the surface-reading, &c.

The height and slope of the banks at each station and their formation will be particularly noted; the marks of floods will be important.

A sounding-rod can be easily made and marked by notches; care must be taken to keep it perpendicular when sounding. When it is not handy or advantageous to use it, employ the line with a one-pound lead; note the nature of the bottom, and the approximate velocity of the current; the length of the canoe will serve as a measure for this purpose if the time of the float passing that distance is noted closely. State in what part of the stream this measure is taken. Compare the sounding-line with the tape-line, and always record the comparison.

Each engineer (second and third) should have an azimuth-compass, if practicable, with a metal circle instead of paper, as the latter is useless after a drenching. The way in which the numbers round the circle increase is to be noted. Take bearings of the gradienter and the other staff as checks, and then upon all objects of interest visible, especially upon any signal that may have been set up to mark the mouth of some stream, &c., and tangents to all bends in the river, estimating their distance, &c.

With the hand-level the heights of the banks should be measured at every staff station; lines of approximate levels may be run to any hillock, &c.

At each stopping-place, observations will be made of the aneroid, with the temperature, time, and its relation to the zero of the staff. The aneroids are to be compared with the steel barometer as often as practicable.

The telescope will be necessary to observe the movements and signals of the first engineer. It should have a graduated *glass scale* in the focus, for obtaining distances; should be substantially made and portable; and should have good definition, with adequate power. One scale is graduated for the average height of a man, (5 feet 6 inches,) as a base, up to 2,000 yards; and also a regular scale of about forty divisions, whose value must be determined before going into the field. I have one in which ten divisions of the scale subtend 10 feet on the leveling-rod at 1,094 yards, and have had capital results at that distance. A table is readily constructed from such figures, and entered with the argument of feet and decimals subtended on the rod by ten divisions.

The 50-foot brass-wired tape-line is to be used to measure and compare the sounding-line, and the line for measuring the width of rivers, and running courses and distances. As far as practicable it will be reserved as a standard and for special measures.

A watch is necessary to note the time of all observations and operations, to be compared as often as practicable with the pocket-chronometer of the first engineer.

Hawser-laid twine (about 500 feet) is required for measuring the width of streams and for sounding them; also for use as a heaving-line over boughs of trees that require ascending.

Each engineer should have two section-books ruled in squares of about ¼ inch; in these should be drawn the general course and features of the river, the height, slope, and formation of the banks; the entrances of other streams; the observations upon mountains, and all topographical details; the widths and cross-sections of streams, &c. One page may be reserved for observations; the other for plan, &c. Each side of the squares may represent 200 feet, and with this considerable detail can be entered according to scale. The squares assist in laying off the angles observed. Full notes should be recorded on the spot, so that the memory may not be taxed to recollect facts about disputed points.

For signals upon which bearings only are required, tack up a square of white signal-stuff with the angles of the square up, so as to present a "diamond" shape. For distance, use a piece 5 feet long and half the width of the cloth. Square flags of this white cloth may be used for flag-signals to communicate with the other boats. For this purpose use the heliotrope alphabet of Appendix B, merely adopting one wave from perpendicular by the *right* to horizontal, as the dot; and one wave from perpendicular to left, as the dash.

APPENDIX A.

INSTRUMENTAL OUTFIT.

CHIEF ENGINEER.—Six-inch vertical circle; pocket-chronometer; pocket-sextant; azimuth-compass, metal circle; hand-level; aneroid, small size; telescope for distances, &c., or opera-glass; 10-foot steel measure for standard; pocket-dividers and scale; note-books, pencils, knife, twine, fish-hooks, matches, hatchet, telegraph-climber, sportsman's filter; rubber haversack; a Davidson heliotrope, on Paca or Pirré, under charge of officer from vessel, with azimuth-compass and sextant.

FIRST ASSISTANT ENGINEER.—Gradienter, with vernier-reader; pocket-chronometer; pocket-sextant; azimuth-compass; hand-level; steel barometer and one pound of mercury; water-level, for reserve; box drawing-instruments; telescope for distances, clamp and screw; small box instrumental tools; Davidson heliotrope; sounding-rod, tape line, 500 feet twine hawser-laid, and one pound lead; tin chart-case; sportsman's filter; backed paper with protractor printed on tracing-muslin; books, pencils, knife, fish-hooks, matches, hatchet, nails, tacks, signal-stuff, telegraph-climber; rubber haversack.

SECOND AND THIRD ASSISTANT ENGINEERS, EACH.—Leveling and distant rod; watch; azimuth-compass; aneroid-barometer; thermometers, wet and dry; hand-level; telescope for distances, &c., clamp and screw; 50-foot tape line, 500-foot hawser-laid line, and one pound lead; spade; sportsman's filter; books, pencils, knife, fish-hooks, matches, nails, tacks, and signal-stuff; rubber haversack.

APPENDIX B.

USE OF THE HELIOTROPE FOR COMMUNICATING MESSAGES, ETC.

Let the two heliotropes show to each other; when each sees the other let them announce the fact by a rapid series of a dozen flashes by passing the hand before the ray and removing it quickly. The recognition being mutually established, and it is desired by either party to communicate any message, show a dozen flashes in pairs, then keep the heliotrope on until the party is ready to commence.

The simplest way of showing signal-flashes, when no mechanical contrivance is affixed to the heliotrope, will be to interpose the hand to cut off the ray, and to remove it for the flash or prolonged flash.

Use the following alphabet for the spelling, wherein the dots represent *flashes*, and the dashes represent *prolonged flashes*. Let the flash be about ¼ of a second duration, the interval the same, and the prolonged flash about ¾ of a second. Practice will determine these times:

a = · —	*j* = — · — ·	*r* = · — · ·	*z* = · — — · ·	7 = — — · ·
b = — · · ·	*k* = — · —	*s* = · · ·	*&* = · · · — · ·	8 = — — · · ·
c = · · — ·	*l* = — · · · ·	*t* = —	1 = · — — ·	9 = — · · · —
d = — · ·	*m* = — · · —	*u* = · · —	2 = · · — · ·	0 = — — — —
e = ·	*n* = — ·	*v* = · · · —	3 = · · · — ·	, = · — · — ·
f = · — ·	*o* = — —	*w* = · — —	4 = · · · · —	; = · · · — —
g = — — ·	*p* = · · · · ·	*x* = · — · · ·	5 = — — —	. = · · — — · ·
h = · · · ·	*q* = · · — —	*y* = · — · —	6 = · · · · · ·	? = — · · — ·
i = · ·				

APPENDIX C.

FORM OF RECORD OF LEVELINGS, COURSES, AND DISTANCES WITH WÜRDEMANN'S GRADIENTER.

The following memoranda must be entered in the first page of the record:

In instrument No. — the horizontal circle reads by vernier to 1′, and the numbers increase with the numbers on watch face. Value of the distance-wires determined —— date —— place. From collimator-wire to either extreme *ten feet* is subtended at the distance of —— *yards*.

Form of record of levelings, courses, and distances with Würdemann's gradienter.

Date.	Backsights.					+	−	Foresights.							
Station.	Needle of zero vernier reads.	Rod reads on circle.	Bearing from N. round by E.	Reduced distances.	Distance-wires subtend on rod.	Leveling rod reads.	Leveling rod reads.	Distance-wires subtend on rod.	Reduced distances.	Bearing from N. round by E.	Rod reads on circle.	+	−	Rise.	Fall.
				Yards.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Yards.*						
1	37–25	287–33	70–08	648	7.2	2.35	3.56	6.4	576	101–15	138–40	......	1.21	......	1.21
2	Etc ...	Etc ...	Etc ...	603	6.7	4.49	6.19	7.3	657	Etc ...	Etc ...	......	1.70	......	2.91
3	......	......	......	531	5.9	9.58	6.21	5.0	450	......	......	3.37	......	0.46	......
4	......	......	......	396	4.4	8.67	7.65	5.2	468	......	......	1.02	......	1.48	......
5	......	......	......	549	6.1	6.07	9.13	5.7	513	......	......	......	3.06	......	1.58
6	......	......	......	324	3.6	5.89	3.72	4.2	378	......	......	2.17	......	0.59	......
7	......	......	......	405	5.5	7.97	4.27	4.8	432	......	......	3.70	......	4.29	Chk.
Etc	......	......	......	Etc ...	Etc ...	Etc ...	Etc ...	Etc ...	Etc	......	......	Etc ...	......	Etc .	......
				3,546	39.4	45.02	40.73	38.6	3,474	......	......	10.26	5.97	......	......
						40.73	......	39.4	3,546	......	......	5.97	......	......	......
						4.29	Check.	78.0	=7,020	Check.		4.29	Chk.		

All notes and memoranda of other courses, vertical angles, &c., will be entered on the page facing the level record, with proper references for identification of station, &c.

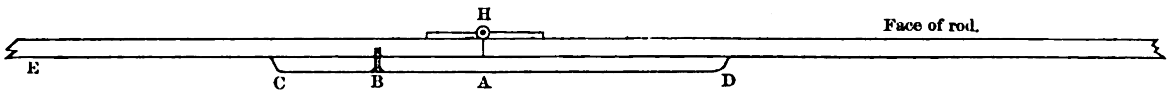
The days upon which observations are made will be known by the letters of the alphabet in addition to their proper designation. For instance, the first, second, and third days of observation will be known as *a*, *b*, *c*, (besides the regular day of the month,) and the stations occupied on these days will be known on the map as a^1, a^2, *&c.*, b^1, b^2, *&c.*, c^1, c^2, *&c.*

APPENDIX D.

ROD FOR LEVELING, DISTANCE, AND STATION-MARK FOR COURSES.

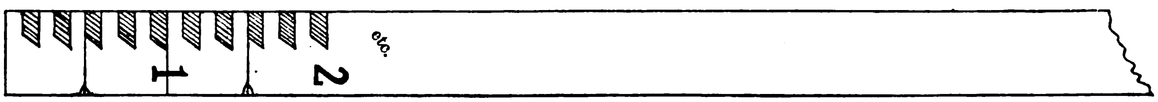
One rod to the second engineer and another to the third engineer.

The rod is proposed to be 12 feet long, 5 inches wide, and 1 inch thick, hinged in the middle for ease of transportation. Two hinges are fastened to the face at H. A batten at the back, about



30 inches long, (CD,) is screwed upon the staff to keep it open and firm when in use. The screw B is the only one through the batten never removed, for when the rod is folded for traveling all the other screws are removed and the batten revolved on this screw so that the long arm BD is turned toward E, when the end C will come opposite H. The batten is then screwed on for traveling and the two faces of the staff screwed together, and in this condition it is slipped into a long sack When once on the exploration, it is not expected that the rod will be folded after once extended.

The rod is painted black or dull red, with white (or tinted) divisions every alternate tenth of a foot, and white block figures. My experience is that the white spaces, by irradiation, overpower



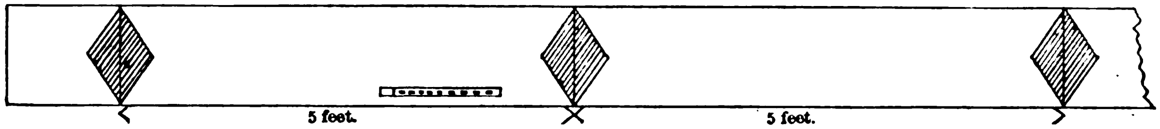
the black spaces as it were, and at long distances in a bright day reduce the apparent size of the black to one-fourth of the white spaces, and hence there is great difficulty in observing and unsatisfactory results. I suggest and intend to try the use of a faint tint to the white, and a change

in the body of the rod from black to dull red, especially as the latter will serve admirably to arrest the eye of the observer quickly when working through dark woods, &c.

The first assistant engineer with the gradienter is to read the leveling-rod himself both for levels and distances, although it would add check to his work to have a temporary target, capable of moving along the edge of the rod, and being elevated or depressed according to signals of the observer, so that the feet and tenths may be checked and noted by the second and third engineers.

With the Würdemann gradienter I have made good observations for distance at 1,100 yards in the cut of a railroad, with a boiling atmosphere; but would not recommend over 500 yards on the river, even if that can be often obtained.

On the back of the rod painted black, (or dull red,) I had painted three white lozenge-shaped marks five feet apart, to be used for distances with any gradienter furnished with micrometer carrying-distance wires, if the observer prefer these marks to the level graduations; and also for the use of the back sight when choosing his new position ahead of the foresight and seeing the back of



his rod. To keep the rod perpendicular, a slab about 10 inches long and 1 inch wide is cut through the rod at any convenient place, and a bullet hung in this by a piece of thread.

APPENDIX E.

Hourly range of the barometer, or corrections to barometric readings, (reduced to 32°,) for any hour of the day, to reduce them to the minimum of the day, subtractive; computed from thirty-nine months' hourly observations, at Girard College, Philadelphia, by George Davidson.

Month.	Mid-night.	1 a. m.	2 a. m.	3 a. m.	4 a. m.	5 a. m.	6 a. m.	7 a. m.	8 a. m.	9 a. m.	10 a. m.	11 a. m.
	Inches.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
January	0.036	.036	.043	.045	.038	.036	.042	.056	.066	.072	.072	.056
February	.037	.036	.032	.026	.026	.028	.033	.039	.053	.059	.059	.056
March	.043	.037	.036	.024	.026	.031	.044	.052	.058	.059	.055	.048
April	.040	.036	.030	.029	.032	.040	.055	.066	.070	.070	.066	.057
May	.028	.022	.018	.020	.022	.035	.048	.058	.063	.062	.059	.052
June	.035	.026	.023	.024	.029	.039	.049	.057	.061	.060	.056	.052
July	.047	.039	.034	.030	.033	.042	.051	.061	.062	.060	.059	.053
August	.033	.028	.023	.020	.020	.028	.041	.050	.053	.056	.052	.049
September	.031	.027	.020	.019	.024	.031	.041	.050	.056	.061	.060	.052
October	.028	.027	.022	.019	.024	.033	.042	.053	.062	.063	.060	.051
November	.043	.041	.041	.040	.040	.046	.049	.058	.067	.070	.069	.056
December	.038	.037	.043	.044	.041	.041	.049	.056	.065	.070	.074	.055
Mean	.037	.033	.030	.028	.030	.036	.045	.055	.061	.063	.062	.053

Month.	Noon.	1 p. m.	2 p. m.	3 p. m.	4 p. m.	5 p. m.	6 p. m.	7 p. m.	8 p. m.	9 p. m.	10 p. m.	11 p. m.
	Inches.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
January	0.031	.006	.000	.004	.006	.015	.024	.038	.037	.038	.037	.034
February	.041	.018	.003	.000	.002	.008	.016	.024	.031	.038	.042	.040
March	.035	.020	.003	.000	.002	.013	.025	.040	.045	.054	.056	.061
April	.043	.030	.017	.007	.000	.004	.010	.019	.038	.043	.046	.051
May	.042	.031	.018	.007	.003	.000	.005	.015	.028	.041	.048	.051
June	.044	.032	.020	.012	.005	.000	008	.013	.022	.029	.039	.039
July	.045	.043	.021	.010	.003	.000	.000	.005	.014	.018	.022	.025
August	.041	.030	.016	.007	.001	.000	.004	.011	.025	.032	.036	.036
September	.043	.026	.011	.001	.000	.002	.007	.012	.025	.036	.040	.037
October	.035	.016	.005	.001	.000	.006	.014	.025	.033	.040	.043	.043
November	.033	.013	.003	.000	.005	.013	.021	.032	.035	.036	.038	.035
December	.031	.010	.001	.000	.002	.008	.015	.022	.026	.027	.029	.030
Mean	.039	.023	.010	.004	.002	.006	.012	.021	.030	.036	.040	.040

APPENDIX F.

TO PACK AND UNPACK AND TO REFILL THE STEEL BAROMETER AS MADE BY WÜRDEMANN.

The wooden case of the barometer forms also its tripod stand. When taking it out of its case, lay it horizontal with the letters U P uppermost; take off the ring clamps, when the two upper legs can be opened, and the barometer found lying in the lower leg. Take out the barometer, set up the stand and pass the upper part of the barometer through the top of the stand from below, and hang the gimbals of the barometer in the bearings in the top of the stand; the barometer will then hang perpendicularly. Turn the cock at the lower end of the barometer by moving the lever upward, when the mercury will rise in the glass cylinder. Make the contact of the point of the piston-rod in the glass cylinder with the surface of the mercury, and read off the scale.

When packing for transportation, bring the barometer nearly horizontal until most of the mercury passes into the glass cylinder, leaving about $\frac{1}{4}$ of an inch in the glass; turn the cock horizontal and pack. It is safest to leave this quantity of mercury out, as otherwise an increase of temperature might force the mercury through, to the damage of the air-tight fittings. The barometer should have a leather case and shoulder strap.

The wrench and steel pin packed with the barometer are used in the operation of refilling the barometer. To do this close the cock, affix the wrench to the upper part of the tube, about 5 inches from the top, where two plain parallel surfaces are worked to receive it. Pass the steel pin through the hole at the top, and unscrew the cap, being careful not to lose the hard-steel plain disk in the top of it. Fill the empty space in the tube with mercury until it is somewhat above the edge of the tube, being careful that no dirt is on the surface or the edge of the tube. Lay the hard-steel disk on the top of the mercury column, put on the cap, and screw down tightly. Then open the cock and let out $\frac{1}{8}$ of an inch of mercury, and remove it carefully from the glass cylinder. Bring the barometer horizontal, and incline it repeatedly that the vacuum may pass over all the small air bubbles in the column. Bring the barometer upright and go through the process of refilling; when the barometer may be judged completely filled, open the cock, and the scale will give nearly the correct barometrical readings.

When a little mercury is let out of the steel tube and the cock closed, it is easy to detect the presence of air above the column by the muffled sound emitted when the mercury, by a quick movement downward of the barometer, is made by its inertia to strike the top of the tube. When the vacuum is perfect, the sound is sharp and clear as metal upon metal.

To get the mercury out of the glass cylinder when necessary, unclamp the slide carrying the steel point and index-vernier, and carefully withdraw it; then remove all the particles of mercury.

APPENDIX G.

METHODS OF ASCERTAINING THE DISCHARGE OF WATER IN ANY STREAM.

Measure the width of the stream, and make sufficiently numerous soundings across it to give its cross-section. If this cross-section is irregular, divide it into partial areas so small that the velocity throughout each may be considered unvarying. The velocity in all parts of the cross-section should be actually measured for close results, and a mean of the velocities taken for the mean velocity of the stream. The discharge of the stream is equal to the sum of the partial areas of cross-section by their respective velocities.

The best method of measuring the mean velocity is by means of double floats; one for the surface, the lower one at a specified depth. Humphreys recommends kegs without top or bottom, with strips of lead to keep them upright, for lower floats; size, 12 inches high, 8 inches diameter, and connected with the upper float by line $\frac{1}{5}$ inch diameter. The upper float of pine board $5\frac{1}{2}$ by $5\frac{1}{2}$ by $\frac{1}{2}$, with flag attached to this float by a foot of wire. The length of line connecting the two floats will, of course, be such as to permit the lower one to sink to a given depth, say mid-depth, of the vertical plane in which the velocity is to be measured. A good substitute for the keg can doubtless be readily improvized from a box, or an ordinary meat-can; in fact, many good substitutes and

methods will readily suggest themselves for approximate results according to the ever-varying circumstances of the case.

The time of the flag passing a measured distance is to be carefully noted, as well as the distance of its course from the shore, &c.

If the stream is small and considerable exactness is required, the boat should be secured at various equidistant stations, the banks being reckoned as two of them, and the actual mid-depth velocity ($V\frac{1}{2}D$) measured by the best available method.

A close approximation to the discharge can be then obtained by using the mean of all the different station mid-depth velocities. In this method there are two causes of error which nearly balance each other, namely, the inequality in area of the different divisions of the cross-section, and the difference between the mid-depth velocity $V\frac{1}{2}D$ and the mean velocity Vm in any vertical plane.

Notation, Formulæ, &c. (Unit=one English foot.)

l=length of a limited part of the river.

$h=h'+h''$=the difference of level of the water-surface at the two extremities of the length l.

h'=that part of h consumed in overcoming the resistances of the channel, supposed to be straight, and of nearly uniform cross-section.

h''=that part of h consumed in overcoming the resistances of bends and important irregularities of cross-section.

$s=\frac{h'}{l}$=the sine of the slope, or the fall of water-surface in one English foot, considering the channel straight and nearly uniform.

H=the fall of water-surface in one English mile.

a=area of cross-section.

p=length of wetted perimeter.

$r=\frac{a}{p}$=mean radius, or hydraulic mean depth.

$r'=\frac{a}{p+W}$=mean radius prime.

Q=discharge in cubic feet per second.

$v=\frac{Q}{a}$=mean velocity of the stream in feet per second.

D=depth of the stream at any given point of the surface.

W=width of the surface of the river at any given locality where the cross-section and velocity are measured.

$V\frac{1}{2}D$=velocity in feet per second, at mid-depth, in any vertical plane parallel to the current.

α=angle of incidence of the water in passing round a bend. It is always assumed about equal to 30°, and the effect of the bend estimated by determining the number of such deflections necessary to pass round it. We, however, give a simpler but empirical rule.

b=coefficient of mean velocity.

M=the *excess* of distance measured by the course of the river over the air-line between given points. This distance measured *in miles* is reckoned as *that many feet*.

From the mid-depth velocities $V\frac{1}{2}D$ in each plane we obtain the mean velocity, by the formula—

$$v=1.075\,V\tfrac{1}{2}D+.004\,b-093\,(V\tfrac{1}{2}D\,.\,b)^{\frac{1}{2}}$$

where—

$$b=\frac{1.7}{(D+1.5)^{\frac{1}{2}}} \text{ and } 1.075 \text{ constant.}$$

If we call a the area of cross-section, and a', &c., the partial division areas, we can find the discharge by—

$$Q = v\,a = [a'\,(V\,\tfrac{1}{2}D) - \tfrac{1}{12}\,(b\,.\,v)^{\frac{1}{2}}]$$

where [ ] denotes the sum of similar quantities.

If the fall of the water-surface is measured by the levelings, and r' determined from actual measurement; or, if v and r' are measured, Humphreys gives the following formulæ:

$$v = ([225\,r'\,.\,s^{\frac{1}{2}}]^{\frac{1}{4}} - .09\,b)^2$$

$$s = \left(\frac{(v^{\frac{1}{2}} + .09\,b)^4}{225\,r'}\right)^2$$

$$r' = \frac{(v^{\frac{1}{2}} + .09\,b)^4}{225\,s^{\frac{1}{2}}}$$

and—

$$b = \frac{1.7}{(r' + 1.5)^{\frac{1}{2}}}$$

$$h'' = \frac{v^2\,\sin^2 a}{134}$$

$$\sin^2 a = \tfrac{1}{3}\,M$$

From these the value of Q can be found for the purposes required in this exploration.

LIST OF SKETCHES.